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ON THE MINUTE MEASUREMENTS OF MODERN SCIENCE.

By ALFRED M. MAYER.

ARTICLE XVIII.

On the Application of Rotating Mirrors to the Measurements of Minute Lengths, Angles, and Times.

THE EXPERIMENTS OF FEDDERSEN, HENRY, ROOD, AND MAYER ON THE NATURE AND DURATION OF THE ELECTRIC DISCHARGE.

If we except a remarkable discovery made by Joseph Henry in 1841, nearly a quarter of a century elapsed before anything of value was added to the information which Wheatstone had given us about the nature of the electric discharge.

In the year 1858, Professor Feddersen, of Leipsic, began a series of elaborate and refined experiments on the electric spark. The peculiarity of his method consisted in replacing the plane mirror, which Wheatstone had used, by a concave mirror (of one-half meter radius), which gave an image of the spark by reflecting its rays on to a piece of finely ground glass. In this image the observer could see the structure of the spark. This is an improvement of prime importance, and the want of it prevented Wheatstone from really seeing what his mirror otherwise would have revealed to him. In fact, as we shall soon see, the spark, as observed by Wheatstone, was so brilliant and minute that its more feebly luminous and colored parts could not be seen. As this brilliant part of the spark has a very minute duration—less than the millionth of a second—it followed that Wheatstone decided that the whole of the electric spark has a duration less than the above fraction of a second.

Feddersen studied the images of the electric spark given by the concave mirror when it was stationary, and then when it was revolving 100 times per second. He made both drawings and photographs of these appearances. Feddersen divides electric discharges into three kinds:

1st. *The continuous discharge.* The rotating concave mirror gives an image of this, composed of a brilliant narrow line joining the electrodes, and parallel to the axis of rotation of the mirror. At the ends of this line, and at right angles to it, appear two faintly luminous bands. The noise given by this kind of discharge is a sharp crack.

2d. *The intermittent discharge,* formed of a series of luminous lines (parallel to the line joining the electrodes), and separated by dark spaces which become wider as the lines are further from the electrodes. This discharge makes a crackling or rustling noise, and appears to the naked eye as "the electric brush."

3d. *The oscillating discharge,* composed of a series of luminous brushes or cones, which start from two lines drawn at right angles to the ends of the line which joins the electrodes. These brushes curve around till they are parallel to these lines, and are alternate in their positions. Fig. 61 shows the appearance of this character of discharge, which was predicted by Henry in 1841, and first actually seen by Feddersen in 1862.

With his mirror running with a velocity of 100 revolutions per second, Feddersen saw the image of the spark of a discharging Leyden jar drawn out to the length of 20 to 30 millimeters. Using a larger jar, he observed that the spark was elongated to 20 millimeters more by the addition of a reddish tail formed of the gradually cooling metal volatilized from the electrodes. He found that an increase of "the striking distance" between the electrodes, as well as an increase of surface of the Leyden jar, gave the spark a longer existence. Thus, with a jar of 2·2 square feet of surface, and the electrodes 1½ millimeter apart, the spark's duration was 1-25,000th of a second; but on separating the electrodes till the spark was 3¾ millimeters long the entire discharge lasted about 1-14,000th of a second. Feddersen also found that by increasing the resistance of the conductor leading from one coating to the other of the jar he greatly lengthened the time of the duration of the discharge. Thus, with a column of water of 9 millimeters in length, placed in the circuit, the duration of the discharge was 1-714th of a second; when a column of water 180 millimeters long, and of the same area of section, was interposed the duration lengthened to 1-54th of a second.

The most remarkable, however, of Feddersen's discoveries was that of the oscillatory character of the discharge of a Leyden jar, the discharge appearing to act like an elastic fluid, which alternately rebounded from the inside and outside coatings of the jar. Fig. 61 is a reproduction of an engraving contained in one of Feddersen's papers, and made from a photograph obtained from the image of the spark, thrown by the rotating concave mirror on to a sensitive plate. No one who examines this remarkable picture can fail to see the oscillatory character of this discharge. The spark was taken from a battery of 16 large Leyden jars with a conductor of high resistance connecting the inside and outside coatings. The electrodes were balls of iron, coated with varnish except at two points, between which flashed the spark. In this picture the positive electrode was at the right, the negative on the left. The spark is not only greatly elongated in a direction at right angles to the line joining the electrodes, but it is discontinuous and formed of curved brushes of light which appear alternately from the electrodes: first, a discharge takes place from the right hand electrode, then from the left, then from right, then from left, and so on. We also remark that the light which forms the brush coming from the negative electrode (and shown in the lowest part of the figure to the left) is streaked or ribbed, while that which next comes from the opposite or positive electrode is continuous and nebulous in its appearance. Then these appearances change places in the next act in the discharge, and the ribbed brush is now on the right and the nebulous one on the left, and so on.

I regard this photograph as one of the notable results of the modern art of experimenting. Here is a permanent record of the most transient of phenomena engraved by Nature herself, and giving the life history of intense physical actions whose whole existence is crowded into the duration of a hundred-thousandth of a second. Yet, in that short time, law has its reign; each circumstance of the transaction, from the generation of the spark till its final impress on the "sensitized" plate, follows in its allotted order and with its proper direction, duration, and intensity.

Speaking of the above experiments, those of Henry naturally recur for this remarkably talented experimenter saw with his mind's eye in 1841 what Feddersen, twenty years afterwards, succeeded in getting on his photographic plate. In a communication to the American Philosophical Society of Philadelphia, in 1841, Henry says: "The discharge, whatever may be its nature, is not correctly represented (employing the theory of Franklin), by the single transfer of an imponderable fluid from one side of a jar to the other; the phenomena require us to admit the existence of a principal discharge in one direction, and then several reflex actions backward and forward, each more feeble than the preceding, until the equilibrium is obtained. All the facts are shown to be in accordance with this hypothesis, and a ready explanation is afforded by it of a number of phenomena which are to be found in the older works on electricity, but which have, until this time, remained unexplained."

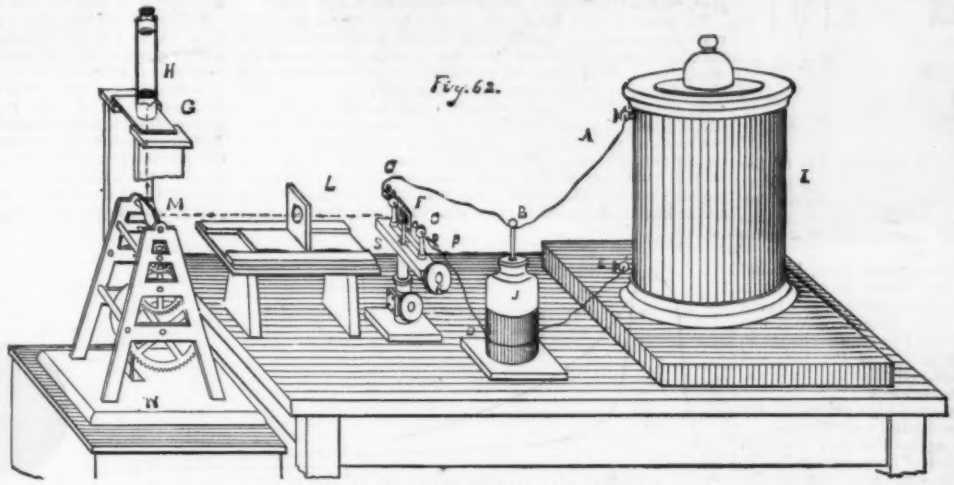
Henry was led to the above conception of the nature of the discharge of a Leyden jar by the observation of the magnetizing action of the discharge of the jar on needles, which were placed in a glass tube, around which a conducting wire was wound like a helix. Now when a needle, placed as above, has an electric discharge sent around it, it is magnetized, and the direction of its magnetism, that is, which of its ends will be N. or S. polarity, depends on the direction of the electric flash through the enveloping helix. But, to Henry's surprise, he found that the same end of the needle was sometimes of north and at others of south polarity, till, after many hundred experiments, he found that there was a connection existing between the direction of the polarity and the amount of charge the jar had, and on the distance over which its spark passed. Then it occurred to Henry that these phenomena could only be explained by the supposition that there were several flows, or oscillations, of the electric fluid, first from one coating to the other of the jar, then back again, and so on, and that the number of these alternate oscillations decreased with the striking distance, and increased with the surface of the jar. Thus the final magnetic condition of the needle depended on the direction and intensity of the last flash of electricity which encircled it. After Henry had premised all this he soon had such mastery over the phenomena that he could at will give to the end of a needle either polarity he wished.

Researches of Prof. O. N. Rood on the nature and duration of the discharge of a Leyden jar connected with an induction coil.—It must have been noticed that Feddersen gives for the duration of the discharge the length of time during which the whole electric explosion lasts; but this explosion is of a complex nature, and the separate acts which compose it now require our attention. The thorough study of the composite nature of the discharge (at least of one form of it) was the subject of a series of skillful researches made in 1869, 1871, 1872, and 1873, by Professor Rood, of Columbia College, New York, of which we will now give an account.

Feddersen's experiments were made on the spark of the Leyden jar kept charged with electricity from a frictional electrical machine. Rood's researches are on the nature and duration of the electric discharge of a Leyden jar which was charged and discharged while in the circuit of the secondary wire of an induction coil. The circumstances of the charging and discharging of a jar placed as in Rood's experiments, are quite different from those which had place in Feddersen's, for, while in Feddersen's the two coatings of the jar were always insulated, in Rood's these coatings were always in metallic connection through the secondary coil of the inductorium, both during the charging and discharging of the jar—"a circumstance," as Rood remarks, "which alone might be supposed to modify the duration of the discharge and its nature; besides this, it is known that the electricity from the coil continues to flow for a considerable fraction of a second along the terminal wires into the jar, which fact renders it questionable whether the duration of the discharge of the jar itself may not be proportionately lengthened. Hence it is evident that it would not be safe to conclude, without experiment, that the results obtained by Feddersen with jars charged with ordinary frictional electricity were applicable to those connected with an induction coil."

Professor Rood in his experiment worked, like Feddersen, on the image of the spark formed on a piece of glass having either a finely ground or a polished surface. He, however, replaced Feddersen's concave rotating mirror with a small plane mirror and an achromatic lens; the latter forming an image of the spark on the plate of glass placed directly over the rotating mirror.

Fig. 62.



PROF. ROOD'S APPARATUS.

Fig. 62 shows the arrangement of apparatus in Rood's experiments. The jar, J, has its inside and outside coatings in the circuit of the secondary coil of the inductorium through the wires leading from A to B, and from E to D. These wires then proceed from B to C, and from D to P. The discharge of the jar takes place between the metallic balls, or pointed wires, on the spark discharger, S. One of these balls is shown on the standard at O. The two standards, carrying the balls or points, can be placed at determinate distances apart by means of a micrometer screw which moves them. The head of this micrometer screw is shown at R.

The rays of light from the spark pass through the achromatic lens, L (of 9 inches focal length), which forms an image of the spark on the ground or plane glass at G, after their rays have been previously reflected from the stationary or revolving mirror at M. The mirror generally used was about one half inch square, and was formed of two silvered mirrors placed back to back. Thus two reflections were obtained from the mirror for one revolution. The image of the spark on G was examined by a microscope, H, which magnified about five times.

The mirror, M, was rotated by the wheel-work, W. Driven by a weight of 30 lb., the mirror could be brought up to a speed of 340 rotations in a second. To measure the rate of its rotation the cylinder on the lowest wheel of the train wound up a fillet of paper, on which dots were made by a Morse register, through which a current was sent by a pendulum at each second. The number of rotations made in a second by the mirror was readily computed from the record thus made on the fillet.

Two Leyden jars were used in Professor Rood's experiments. The larger of these had a coating of 114·4 square inches of foil, the smaller had only 11 square inches of surface. The discharge of the larger jar differed from the smaller both in its nature and in its duration.

Professor Rood first began a careful study of the structure which the spark presented when its image was formed by reflection from the stationary mirror.

Placing the larger jar in the circuit and sending its sparks between pointed brass wires one millimeter apart, the image of the spark on the glass surface at G appeared as in Fig. 63 *a*; "a central white portion surrounded by a yellowish envelope, which in the figure* is shown by the coarse shading; the second envelope, more densely shaded, being green and much inferior in brightness. With a striking distance of ten millimeters, the green envelope was produced only in the neighborhood of the electrodes, as shown at B of Fig. 63. In both cases a number of minute jets of white light were seen to issue from the electrodes; these are only partially shown in the figures. The green color was due to the heated particles of metal, and the bright points of light to successive discharges, as will be shown further on."

With fine platinum wires for electrodes the appearance was the same as with the pointed wires, except that the green tint was replaced by a gra, or violet-gray hue.

* This and the remaining figures describing Professor Rood's work I owe to the kindness of Professor Dana, editor of the *American Journal of Science.*

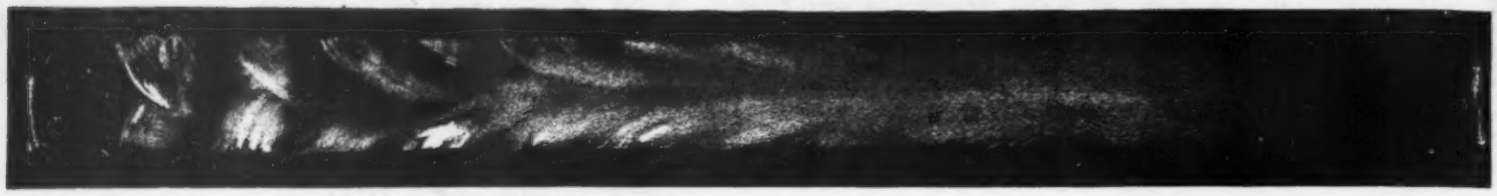


Fig. 61.

On examining in the same manner as above the spark given by the smaller jar, it appeared almost entirely composed of a bright white core.

Appearances of the images of the sparks when these are reflected from the rotating mirror.—Using the larger jar of 114·4 square inches area of coating, and brass balls as electrodes. "With a striking distance of one or two millimeters, the image being thrown on the ground glass and viewed with the naked eye, it was found that the spark was drawn out into a streak one and a half or two inches long, according to the rate of the mirror; the portion at W, Fig. 63*a*, was white; this shaded into a brownish yellow tint, B Y, the latter passing into a pretty distinct green, G. It will be found by comparison that this result is exactly that obtained by Feddersen with frictional electricity, except that in my case the green color of the tail seems to have been much stronger, which is explained by the low intensity of the illumination.

"With the unaided eye and ground glass, nothing additional of a remarkable character could be discerned, but on using the polished piece of glass and an eye-piece magnifying

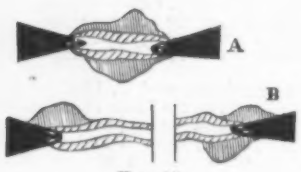


Fig. 63.

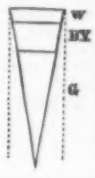


Fig. 63 *a*.

five diameters, a series of bright dots on each side of the streak became visible in the positions indicated by the dots in Fig. 64. These resemble the photographs obtained by Feddersen with frictional electricity. Here it is seen that the bright points before spoken of correspond to a series of discharges following the first.

"With platinum points, using the ground glass, I found that the form of the streak was sometimes identical with that produced from brass balls, the green color merely being replaced by a violet-grayish tint. The form, however, was more often quite different, as shown in Fig. 64, the change in shape being due to the partial suppression of the tail, and to its irregular production; with low velocities the shape was often as in the smallest of the three sketches.

"With eye-piece, polished glass, and high velocities, the series of bright points was seen beautifully developed.

"With brass points, this same figure was produced, yet not quite so distinctly. The tail was of course green."

On the duration of the whole discharge and on the times during which exist its separate parts.—Total duration of the discharge.—Rood found that sparks of three millimeters were drawn out in the revolving mirror to a total length which showed that the duration of the whole discharge was about ·00005, or 1-20,000th of a second.

The duration of the yellowish portion of the spark he found to be about ·000005, or the 1-200,000th of a second, which gives to this portion of the spark a duration of only one-tenth of the time occupied by the whole discharge.

The duration of the white portion, or core, of the spark.—Professor Rood now approached a portion of his work which was to tax severely his skill and patience. As yet no

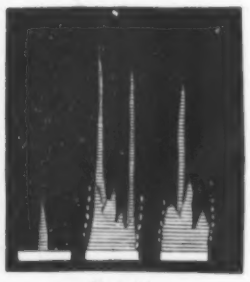


Fig. 64.

experimenter had succeeded in seeing in a rotating mirror any difference in the width of the white core of the spark from what it had when viewed in the mirror when stationary. This clearly showed that the first, the most brilliant, and chief act of the discharge had a duration which was certainly less than the millionth of a second. How much less no one knew. Here we had better give Professor Rood's own words: "Up to this time I had been able to obtain no evidence that the duration of the white band was other than instantaneous; indeed, with this mode of experimenting the contrary cannot be proved. The preceding analysis had shown that a large portion of the light of the spark resided in this white band, *i. e.*, in the first discharge, and when points were used as electrodes, its superior brightness isolated it from the rest of the streak. To ascertain whether it was to be regarded as a separate act by itself, or as only the beginning of a continuous action (of which the yellow portion of the spark was part) lasting ·00005 of a second or longer, I made the following simple experiment: Instead of receiving the light of the spark directly on the achromatic lens, L, Fig. 62, it was used to illuminate a strip of white paper ·14 of an inch in breadth; this was placed horizontally, the direct light from the spark being prevented from reaching the lens by a screen. The striking distance was 1·3 millimeters. With low rates of rotation, the appearance of the image of the band viewed by an eye-piece magnifying five diameters, was quite unaltered; as the rates of rotation were increased the illumination of the image of the band grew fainter, but with the highest velocity, 223 per second, it was distinctly visible and of the same breadth, as far as could be ascertained by the use of the micrometer. This proves, of course, that the first discharge is a simple act, and isolated from those that follow. Next, as an appropriate termination to this experiment, I blackened all the surface of the strip of white paper except so much as served to form a square. On examining the image of this with the same rate of rotation, the square was tolerably visible; it was followed by a faint flame-shaped tail, corresponding to the yellowish portion of the discharge.

"Having thus proved the existence of an isolated discharge, at once the first and most brilliant act in the explosion, a method was contrived for measuring its duration, or, at all events, for setting a limit to it on at least one side. Ordinary micrometric methods, conducted on the naked spark or on a strip of paper illuminated by it, were out of the question, and would have served no purpose except to lead the observer into error, so I continued the following plan, which is moderately easy of application and safe."

We proceed with Professor Rood's account of his race with the spark, only substituting certain corrections which the Professor pointed out in a subsequent portion of his paper. "A small piece of card-board was ruled with two black lines; their distance apart was ·0067 inch, and they were separated by a space exactly equal to the width of a single line. A small dividing engine was used for their production; they were tested with a microscope. These lines were illuminated by the spark and their image (reflected from the mirror) was examined by an eye-piece magnifying five diameters. The breadth of the image of a single line on the ground glass was ·011 inch, that is, each line subtended an angle of 2′ 24″, reckoning from the mirror. With a velocity of 223 per second, the mirror is able to move the reflected image through twice 2′ 24″, or 4′ 48″, in the ·00000048 of a second. If, now, this first discharge (the white core of the spark) had actually lasted this minute portion of time, it is evident that the motion of the mirror would have just carried the image of one of the black lines forward, so that at the end of this infinitesimal period (·00000048th second), it would have occupied the space where just before the adjoining black line had been traced. Hence, owing to the retention of impressions on the retina, the white central line could have been obliterated, and in the place of three lines, a gray band would have been seen. On the other hand, if the duration had been only 1-10th or 1-5th of the above mentioned interval, the white line, not having been much encroached on, would still have remained visible. The correctness of the above reasoning can be experimentally proved, by means of a revolving disk of card-board having a single slit cut in it, lines being drawn on its white side, and viewed by reflection from a mirror through the slit, the blackened side of the disk being turned toward the eye.

"To facilitate matters, three sets of these lines were drawn on the small card-board at considerable distances apart to prevent confusion, and while illuminated by the electric spark were examined with increasing velocities. With low rates they were quite unchanged in appearance; with a velocity as high as 103 rotations per second, a duration in the first act of the discharge of ·000001 second would just have obliterated them; they were, however, perfectly distinct, though faintly traced. The rate of rotation of the mirror was then by degrees carried up to 223 per second, when the lines were still distinctly visible, though, of course, with less contrast between the white and black than was the case with low velocities or a stationary mirror.

"This experiment proves, then, that the duration of the light accompanying the main act of the discharge is considerably less than ·00000048th of a second, probably less than half this period, or less than one five-millionths of a second of time. To make the observations required some patience, as it was necessary to use an eye-piece, the ground glass being replaced by a plane polished plate, and it was seldom that the image of the lines fell exactly in that portion of the field to which the attention was directed. To obviate this difficulty, I afterward covered a piece of card-board half an inch broad with alternate white and black lines of this character; their real width was ·0075th inch, the image of this width on the plate of glass being ·0125th inch. With this I repeated the above mentioned sets of experiments with rapidity, obtaining with ease the same result, as some of the lines were almost certain to be in the right part of the field of view. It is thus shown that the first act of the electric explosion lasted through an interval of time so short as to be immeasurable with the means then at my disposal; it is not impossible that it may still be reached by the use of finer lines and a lens of greater focal length.

"From the foregoing it appears that if a jar having a metallic coating of about 100 square inches be connected, as above described, with an induction coil, its discharge will be effected by a considerable number of acts, of which the first is by far the most intense. Farther, the metallic particles, heated up by the first discharge to a white heat, almost instantly assume a lower temperature, marked by a corresponding change from white to brownish yellow, and as their temperature continues to fall the tint changes in the case of brass electrodes to green, in that of platinum to a gray or violet-gray. A spectroscopic examination of these isolated tints would be interesting, but not without difficulty. These observations further demonstrated the fact, that four ten-millionths of a second is an interval of time quite sufficient for the production of distinct vision.

"When the light from the spark is received directly on a plane revolving mirror, and viewed by the eye as in Wheatstone's original experiment, only the white unanalyzed portion of the spark is ordinarily visible; at least, in repeating the experiment a few times, it is all that I saw. Its form is, of course, that of the spark itself. In all probability this is also the case in a jar charged by frictional electricity, and may serve to explain the great discordance between the results obtained by Wheatstone and Feddersen, the method used by the former furnishing only a view of the first act, the eye being too much dazzled to perceive those that are subsequent and of far less intensity."

Failing to obtain any apparent sliding of the fine black lines on to the intervening white spaces, even when the mirror was making 223 rotations in a second, Professor Rood increased the velocity of the mirror till it made 340 rotations in a second, yet the ruled lines (though only separated by 67-10,000ths of an inch) remained separated, and appeared as they did when viewed reflected from the stationary mirror. With the velocity of rotation of 340 times a second the ruled surface of the paper would have melted into a uniform gray tint had the white portion of the spark lasted only for three millionths of a second. Nothing more could be done with paper, which was now replaced by a glass plate, slightly

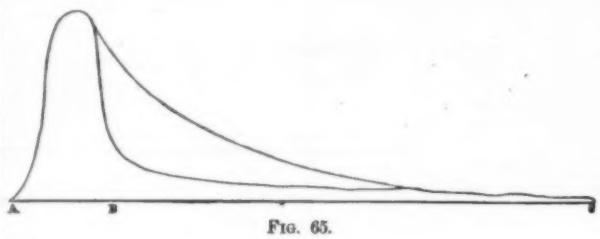


Fig. 65.

Fig. 66.

Fig. 67.

smoked with a lamp, and the lampblack fixed to the plate by flowing alcohol over it. This acted like a cement with the slight amount of resin in the lampblack, and gave a fine black surface, on which lines could be ruled by a finely pointed tool in a small dividing engine. After many trials and microscopic examinations a plate was obtained on which the lines were separated by black spaces of a width exactly equal to the breadth of one of the lines. These lines were so fine that the width of the image of one of them measured on the glass plate at G, Fig. 62, was only the 1-300ths of an inch. This ruled plate was placed at F, close to the fine platinum wires between which the spark passed. Thus placed the lines were brilliantly illuminated by the electric discharge, and a very distinct image of them, showing as bright lines on a dark ground, was formed on the glass, at G, by the action of the lens, L, Fig. 62.

With these fine lines Professor Rood at last succeeded in determining the duration of the white core of the discharge. As the velocity of the mirror approached 180 rotations in a second the lines became fainter and fainter, and, finally, when the mirror had reached 183 rotations in a second, the lines disappeared, showing that the duration of this portion of the discharge was ·000000175 of a second.

On the duration of the white portion, or core, of the spark given by the smaller jar with a coating of eleven square inches.—It had already been shown by Feddersen that the total duration of the discharge of a Leyden jar diminished with the surface of its coating, and Rood had observed that there was little or no difference in the appearance of the spark given by this smaller jar, whether observed in the stationary or rotating mirror.

The ruled smoked plate of glass remaining at F (Fig. 62), as in the previous experiment, and the larger jar, at J, having been replaced by the smaller one, Professor Rood found that the velocity of 183 turns per second on the mirror which had obliterated the lines when they were illuminated by the larger jar, failed to have any effect on the distinctness of these same lines when lighted by the flash of the smaller jar. He then urged the mirror till its velocity reached 340 in a second, yet the lines were unaffected, and appeared just as they did when looked at by the same light reflected from the stationary mirror, though the time required in the spark for their obliteration, with a velocity of 340 per second, was only the ninety-four billionths of a second! "Still," as Professor Rood remarks, "on experimenting, it was evident that the duration of the discharge was less than this quantity, as the lines were plainly to be seen."

"Before finally abandoning the attempt to determine the

actual duration of the discharge, another effort was made. A second lampblack plate was prepared, in which the breadth of the image of a line, black on white, on the observing plate was 1-600th of an inch. These lines were viewed with the terrestrial eye-piece of a small telescope, it enlarged them ten diameters and care was taken with all the adjustments so that a good clean image should be produced. Platinum wires of 1-86th of an inch in diameter were used, with a striking distance of five millimeters. By gradually increasing the driving weight it was proved successively that the duration was less than eighty, sixty-eight, fifty-nine,

FIG. 68.

fifty-five billionths of a second; and finally, the lines, after growing fainter and fainter, entirely disappeared, giving as the result a duration of forty-eight billionths of a second. In a large number of observations I could detect no discharge lasting during a smaller interval, though the apparatus was now fully capable of making evident much smaller periods of time.

"When the striking distance was reduced to one millimeter, the duration was shorter; in the case of 5-6ths of the sparks, the duration was slightly greater than forty-one billionths of a second, the remaining 1-6th being slightly less than this figure.

"With a striking distance of three millimeters, the duration was between forty-one and forty-eight billionths; and when the striking distance was increased to ten millimeters, it was between forty-eight and fifty-five billionths of a second.

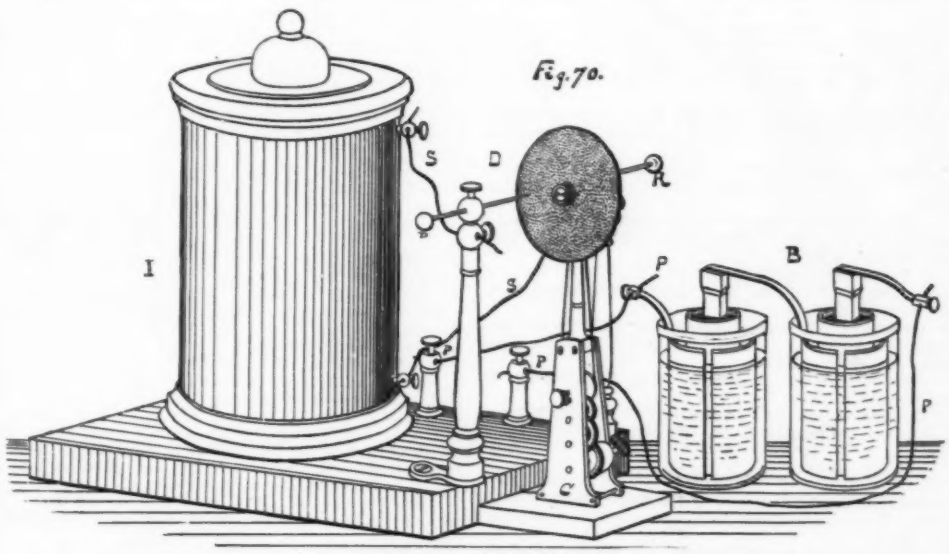
"It has thus been shown that the duration of the first act of the electric discharge (of this small jar) is in certain cases only forty billionths of a second, an interval of time just sufficient for a ray of light to travel over forty feet."

Professor Rood adds: "With another ruled plate I found it practicable to measure intervals as small as twenty-eight billionths of a second; and the mere act of increasing the focal length of the lens, L, would admit of the experi-

FIG. 69.

menter reaching a quantity as small as ten billionths—probably without much difficulty—though it would be necessary to pay more attention to the correction of the optical part of the apparatus, and the observations would naturally consume threefold as much time."

Professor Rood gives, in his paper, the accompanying curve, Fig. 65, by which he shows the duration of the whole discharge and the relative brightness of its various parts. The time during which the discharge lasts is represented by the length of the horizontal line, A C, and the relative degrees of brightness of the discharge at points of time, measured on the horizontal line, A C, are represented by the perpendicular distances of the curve (the unbroken line) from those points on the horizontal line. This curve shows that there is no break in the discharge; it is a continuous act. The steep peak, A B, stands for "the first and most brilliant act of the discharge;" though with the larger jar, of 114 square inches, it is neither so steep, as in the present case, nor so solitary, being followed by a series of minor elevations, while with the small jar the effective luminosity of the discharge is almost wholly concentrated in it; the far greater brilliancy of the light at the beginning of the discharge practically separates it from what follows, and makes



MAYER'S APPARATUS FOR ANALYZING THE ELECTRIC DISCHARGE.

it a first distinct act, whose duration, as we have just seen, Rood measured, and showed that its existence lasts for only forty billionths of a second.

After the success of his remarkable experiments, in which Rood showed that the flash of light from the small jar lasted for only forty billionths of a second, he made some very curious reflections on the very short time necessary for distinct vision. We will give his own words: "I obtained and measured sparks the duration of whose main constituent was only forty billionths of a second. With their light distinct vision is possible; thus, for example, the letters on a printed page are plainly to be seen; also, if a polariscope be used, the cross and rings around the axis of crystals can be observed with all their peculiarities, and errors in the azimuth of the analyzing prism noticed. There seems also to be evidence that this minute interval of time is sufficient for the production of various subjective optical phenomena: for example, for the recognition of Loewe's rings (using cobalt glass); also, the radiating structure of the crystalline lens can be detected when the light is suitably presented to the eye."

Hence, it is plain that forty billionths of a second is quite sufficient for the production on the retina of a strong and distinct impression; and as the obliteration of the micrometric lines in the experiment referred to could only take place from the circumstance that the retina retains and combines a whole series of impressions, whose joint duration is forty billionths of a second, it follows that a much smaller interval of time will suffice for vision. If we limit the number of views of the lines presented to the eye in a single case to ten, it would result that four billionths of a second is sufficient for human vision, though the probability is that a far shorter time would answer as well, or nearly as well. All of which is not so wonderful, if we accept the doctrines of the undulatory theory of light; for according to it, in four billionths of a second, nearly two and a half millions of the undulations of light reach and act on the eye.

On the multiple character of the discharge of the induction coil.—In the course of his experiments on the electric discharge Professor Rood observed that the explosive act of the induction coil was not concentrated into a single spark, but was formed of several distinct flashes, which, it is true, to the naked eye appear as a single flash; but on examination in the revolving mirror this apparent single spark appears as formed of several distinctly separated sparks. Professor Rood used two instruments in his study of these multiple discharges, viz., the revolving mirror already described, and a rotating disk with a slit cut out of it in the direction of one of its radii. If we look at a sheet of white paper through this slit while the disk is rotating, and the paper is illuminated by one instantaneous flash, we evidently will see the slit on the disk appear as a white radial band. If, however, the discharge, as usually is the case, is formed of several distinct and separated sparks, each spark will in order illuminate the slit, and we will see a white radial band on the disk for each separate spark; provided, however, that these sparks do not follow one another so rapidly that the disk has not time enough to carry the slit far enough to prevent the bright radial bands from blending into one broad band.

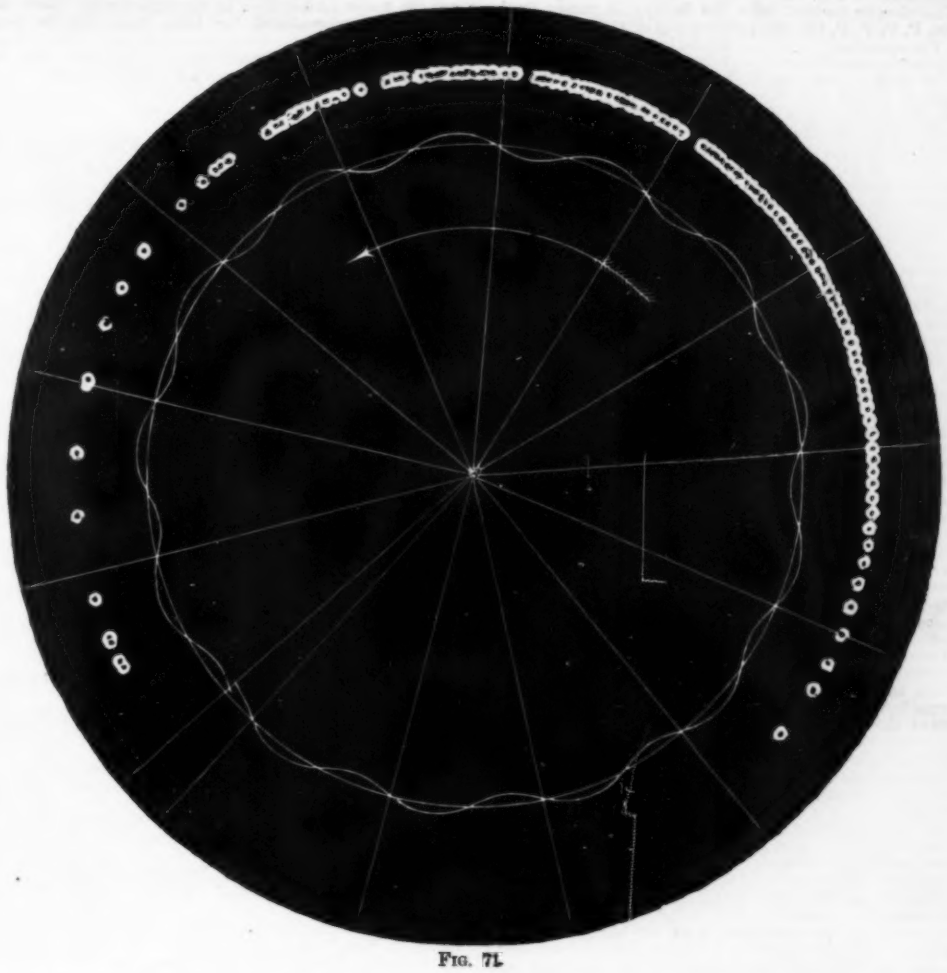


FIG. 71.

To facilitate the observations on these complex phenomena Professor Rood devised what he called a micrometer-disk, formed of two disks superposed. Each disk had a radial slit cut in it, and one of these disks revolved on the other so that the slits could be placed at various angular distances apart. Fig. 66 shows the disks of blackened cardboard with the two slits. On viewing through the revolving disk the white paper surface, illuminated by the electric flash, the slits in the disk appeared as in Fig. 67. By revolving the inner disk on the larger one the two fan-like images of the multiple slits could be brought together so that the end of one just touched the beginning of the other, and thus the angular breadth of the set of multiple slits was readily measured. This measure, with the knowledge of the velocity of rotation of the disk, gives us the data for computing the total duration of these discharges.

Flashing the discharge of his coil between brass balls one millimeter apart, and viewing the discharge in the rotating mirror, the appearance of the flash was as in Fig. 68, showing that sometimes the discharge was formed of three separate sparks, and sometimes of four. The duration of the whole discharge was about 1-165th of a second, the interval separating the sparks being about 1-500th of a second. With a striking distance of two millimeters be observed only one spark.

With platinum points as electrodes, and separated 1, 2, 3, 4, and 5 millimeters, the number of sparks observed at these respective distances of the electrodes was 4, 3, 2, 1 and 1, showing that an increase in the striking distance of the discharge diminishes the number of its component sparks. Placing in the circuit of the induction coil the small Leyden jar of eleven square inches of surface, and sending the discharge between brass balls separated by one millimeter, the character of the discharge, as shown by the revolving mirror and of the rotating disk, was more complex. Fig. 68 shows the appearance it presented on the revolving mirror. Here we see that the act of discharge was formed of a bright spark followed by a violet discharge, extending from C to A, and the latter followed by four sparks, extending from A to B. The total duration of these discharges was 1-50th of a second. The violet portion, C A, lasted for 17-1000th of a second, and the four sparks, between A and B, lasted the 9-1000th of a second. Other forms were sometimes present, like that in Fig. 69, consisting of a faint violet streak terminated at each end by a spark, the whole duration being about 1-35th of a second.

On increasing the striking distance between the balls to 2, 3, 4, 5, 6, 7, 9, and 10 millimeters, the total number of sparks forming the discharge for these striking distances was respectively 5, 8, 4, 3, 3, 3, 2, and 1 spark.

Professor Mayer's Experiments on the Electric Discharge of the Induction Coil.—Professor Rood's mode of experimenting is not competent to unravel the tangle of sparks composing a flash from an induction coil, for the number of separate electric actions forming the discharge are far too many ever

to be viewed in a revolving mirror or to be detected and counted in the multiple images of a slit cut in a rotating disk.

The writer of these articles, in 1874, invented "A new method of investigating the composite nature of the electric discharge," in which the whole life history of a flash from the coil is permanently recorded by the discharge itself on a rapidly revolving disk of smoked paper. The apparatus used is very simple, and will be readily understood after an examination of Fig. 70.

The electric current from the battery, B, passes by the wires, P, P, P, P, into the primary coil of the inductorium, I. The secondary current of the coil, obtained on breaking the primary circuit, passes over the wires, S, S, to the points at the ends of the rods, R, R, between which flashes the discharge of the coil. A disk, D, of thin printing paper, about 15 centimeters in diameter, rotates between the above-mentioned points with a velocity of from 20 to 30 turns per second, given to it by the train of wheelwork, C. If, while the plane of the disk is thus moving between the points, you flash the discharge from the inductorium with a Leyden jar in circuit, the discharge perforates the disk and leaves on it a permanent record of its character, which is shown by the dissipation of the lampblack from off the paper in a series of little circles, giving to the disk the beaded appearance shown in Fig. 71. Each of the white circles has been made by one of the flashes, or separated acts, which this simple experiment shows the discharge of the coil to be composed of.

The thin printing paper is smoked by wrapping it around a cylinder, which is then revolved over burning camphor. The paper is removed from the cylinder, and disks of 15 centimeters in diameter are cut out of it. One of them is carefully centered on the axle of the rotating apparatus, C, and the spring driving the train of wheel-work is fully wound up. The thin paper disk soon reaches a velocity of rotation that causes the centrifugal action to flatten it out, and then it can be slid between the discharging points, even when these are only 3-4 of a millimeter apart.

After the disk has run for a certain number of minutes by the watch, the discharge is passed between the points and through the disk. At the same moment or immediately afterward a delicate tip of foil attached to the end of a prong of a vibrating tuning-fork is brought to touch momentarily the disk Thus is made the wavy line which is seen in the figure just within the white circles made by the dissipation of the lampblack by the electric discharge.

The fork made 256 vibrations in one second (as determined by the method described in Article XVI. of this series), and hence a complete wave of the fork, that is, a flexure toward the edge of the disk together with a flexure toward the center, is traced in 1-256th of a second time. Thus the circumference of the disk is divided off into 1 256ths of a second. To read subdivisions of these small units of time we cut these tuning fork waves by the circumference of a circle, whose center is the center of the disk. This circumference, as an axis, divides the waves symmetrically, so that a flexure without or within the circle equals 1-2 of 1-256th, or 1-512th part of a second. The length of these separate flexures can readily be subdivided on the circumference which cuts them, so that I have been able readily to read off from the disk fractions of time as small as the 1-20,000th of a second.

The disk, of which we give a very careful copy in Fig. 71, revolved between the points in the direction of the arrow, so that the very regular beading on the disk was made toward the end of the discharge.

These records of the history of these remarkable actions which have such short existences have been permanently preserved by floating the disk, after the experiment, on the surface of alcohol to which has been added a few drops of spirit varnish.

Many new results have been obtained with this apparatus. I have space only to describe three experiments made with the large inductorium of the Stevens Institute of Technology, which gives an electric flash of 21 inches in length.

1. *Discharge of large inductorium between platinum points one millimeter apart. No Leyden jar in the circuit.*—The platinum electrodes were neatly rounded and formed on wire 6-10 millimeter in diameter. After the discharge through the rotating disk nothing was visible on it, except a short curve formed of minute thickly set dots; but, on holding the disk between the eye and the light, it was found to be perforated with 33 clean round holes, with the carbon undisturbed around their edges. The portion of the discharge which makes these holes lasts 1-23d of a second, and the holes are separated by intervals which gradually decrease in size toward the end of the discharge, so that the last spark-holes are separated about one-half of the distance which separates the holes made at the beginning of the discharge. The average interval between the spark-holes is 1-750th of a second. After this portion of this discharge has passed there is a period of quiescence lasting about 1-1000th of a second; then follows a shower of minute sparks, which forms the short dotted line above spoken of. This spark-shower lasts 1-330th of a second, and is formed of 30 sparks; hence the average interval of time separating these sparks is 1-9900th of a second. The intervals separating these minute sparks, however, are not uniform, but are smaller in the middle of the spark-shower than at the beginning and at the end of this phenomenon. The spark-shower, indeed, is a miniature of the phenomenon obtained when a Leyden jar is placed in the circuit of the coil, and which is described below. The above numbers were determined as the average measures on six disks. It is here to be remarked that all of the discharges studied in this paper were made by suddenly depressing the platinum faced "break" of the primary circuit, and the break was held in this position until the disk had been removed from between the points or balls.

2. *Discharge of large inductorium between platinum points one millimeter apart, with a Leyden jar of 242 square centimeters of surface of foil, connected with the terminals of the secondary coil.*—After this discharge through the disk a very remarkable appearance is presented. The discharge in its path around the disk dissipates little circles of carbon. (See Fig. 71.) There are 91 of these little circles, each perforated with either 4, 3, 2, or 1 hole. I shall here have to adopt a new nomenclature for the description of this complex phenomenon. I call the whole act of discharge of the coil, the discharge. Those separate actions which form the little circles by the dissipation of the carbon I denominate flashes, and the perforations in these circles I shall call sparks. The discharge in the above experiment lasted 1-24th of a second. The flashes at the beginning of the discharge are separated by intervals averaging 1-555th of a second up to about the 10th flash; after this the intervals of the flashes rapidly close up, so that during four-fifths of the discharge they follow each other at each 1-5882 of a second. During the last fifth of the discharge the intervals between flashes gradually increase, and the last flash is separated from its predecessor by 1-1000th of a second.

3. *Discharge of large inductorium between brass balls, one centimeter in diameter, separate one millimeter, with a Leyden jar of 242 square centimeters of inner coating in the circuit of the secondary coil.*—This discharge also lasts 1-24th of a second, and is similar in character to the preceding, except that larger circles are made in the disk by the dissipation of the carbon, and that there are fewer flashes, viz., 71. The total number of spark-holes in these flashes is 123. Thus, there are fewer flashes than in the experiments where the platinum points replaced the brass balls, but the total number of spark-holes is the same in each case. Hence there is, on an average, 1-34 spark-hole to each flash with the points, and 1-73 spark-hole to each flash with the balls.

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NOTES ON THE MICROSTRUCTURE OF SPIEGELEISEN.

CONDENSED FROM A REPORT BY A. MARTENS TO THE SOCIETY OF GERMAN ENGINEERS.

FRACTURES.

IN spiegeleisen, cavities are frequently found, partially filled with tabular crystals protruding to about half of their length into the hollow space. From the ends embedded into the solid mass lines issue, running in vertical direction to the cooling surfaces of the piece from which the sample was taken. Along these lines the iron splits easily, with smooth surfaces. The crystalline plates within the cavities are arranged like the leaves of a fan or a book, and the groups thus formed intersect each other frequently. Fig. 1, next page, represents schematically the mode of intersection. Some of those books contain as many as fifty leaves, the thickness of which varies from 0·029 to 0·039 of an inch. Their edges are lined with a row of fine teeth, formed by bundles of minute crystals, a certain number of which always issues from one central point. The surface of the large crystals is covered with parallel lines or bands forming angles of 60° and 120° with each other respectively. Surfaces of this character are represented by Figs. 2*a*, 2*b*, and 3. Fig. 2*a* shows plainly that these lines are formed by rows of rectangular crystals protruding over the surface and penetrating the film of oxide covering the latter. Hereby parallel grooves are formed between the rows of crystals, into which the oxide has been crowded so as to form numerous folds and elevations. This shows that the oxide was formed before solidification. Fig. 2*b* illustrates the character of this structure, and Fig. 3 is a more theoretical representation of the same. The crystals form angles of 60° with the general direction of the rows. The large tabular crystals are, near the point of intersection, frequently bent out of shape, as shown in Fig. 4. It will also be noticed that the vertex of the obtuse angle, *a*, Fig. 1, is sharply defined, while the lines forming the angle β seem to run together a short distance from the point of intersection.

When the surface of a tabular crystal is treated with dilute muriatic acid (1:3) in order to remove the oxide and adhering foreign substances, these figures become more clear and comprehensive. The crystals protruding from the surface are more distinctly visible.

The surface of these crystals is covered with peculiar figures and lines (Fig. 2*b* and 3), forming right angles with the long axis of the crystals. The examination of these "etched figures" is very interesting and promises to furnish much information, especially as similar figures have already been observed on the polished surfaces of several samples of other iron. A magnification of 100:1 is best adapted for their observation.

When heated, these figures acquire and pass through successive shades of yellow, red, green, and blue, and those portions that resist longest the action of the acids are also slowest in changing colors. On such portions they are less intense and more glossy.

Supposing our sample of spiegeleisen to be a mixture of pure iron, iron containing a small quantity of carbon as a mechanical admixture, and spiegeleisen proper, Fe_4C, manganese, silicium, etc., and that, corresponding to a regular, systematical arrangement of these different substances throughout the entire mass, they be arranged in this manner also in the small crystal forming our object, we may, from the general appearance of the etched surface, conclude that spiegeleisen, Fe_4C, is less affected by acids than the surrounding portions of pure and slightly carbureted iron. And we may infer that, the other constituents being brought into similar relations with the iron, they will exercise similar influences, determined by their special character.

It must, however, not be overlooked, that the deepest portions of these etched figures, where consequently the body of our object is thinnest, shows the colors sooner than the elevations or thicker portions.

In considering the surfaces obtained by splitting a piece of spiegeleisen, we find them generally to be of a silver white color and very smooth, but frequently interrupted by cracks and crevices, on the walls of which will be found formations similar to those observed in the larger cavities. Magnified about fifty times, the surface shows a scaly texture, as represented in Fig. 7 and 7*b*. The latter is a detailed theoretical representation. Numerous thin, indistinctly defined, minute scales are superposed upon each other and their edges seem to have a tendency to develop in two directions chiefly, forming right angles with each other. Hereby the entire structure receives a peculiar character, which is yet strengthened by a number of lines running in the same direction. These are formed by the shadows of undulations, which probably correspond to the rows of crystals observed in the crystalline plates of the cavities. On the surface of a transverse fracture the scales will be noticed protruding to some extent (Fig. 7*a* and *b*). I estimate their thickness at from 0·0003 to 0·0011 of an inch. Pictures, extremely difficult to be reproduced by drawing, are formed by peculiar deposits, resembling in form mossy growths, branches of trees and fern leaves, and affording magnificent views indeed under the microscope. I have attempted to reproduce some of them in Figs. 8, 9, and 10. They are not unlike the pictures formed by the ice on window-panes.

EXPLANATION OF FIGURES.

Fig. 1. Schematic representation of intersection of crystals in cavities.
Fig. 2. Figures on the surfaces of crystals, 30:1.
Fig. 3. Theoretical representation of figures.
Fig. 4. Two crystals, bent out of shape at point of intersection, 20:1.
Fig. 5. Figures on the surface of crystals, 40:1.
Fig. 6. Surface of a crystal with etched figures, 180:1.
Fig. 7, *a*, *b*, *c*. Surface of split spiegeleisen, 70:1.
Fig. 8. Moss, tree and fern shaped figures, 80:1.
Fig. 9*a*. " " " " 350:1.
Fig. 9*b*. " " " " 100:1.
Fig. 10. Transverse fracture of spiegeleisen.

(*To be continued.*)

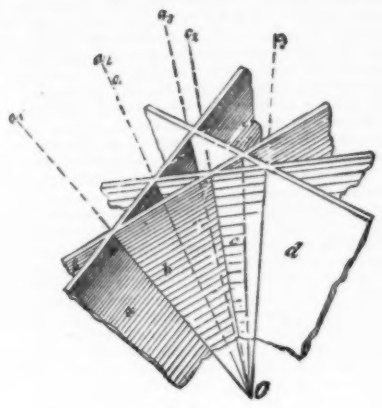


FIG. 1.

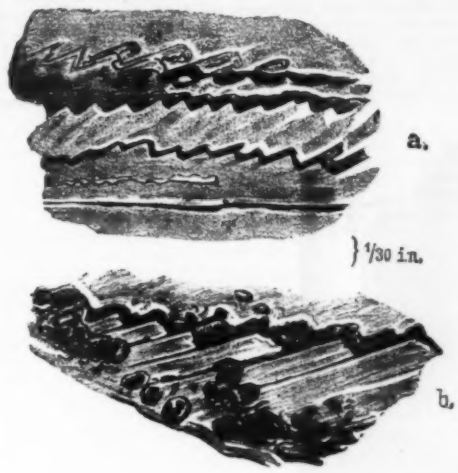
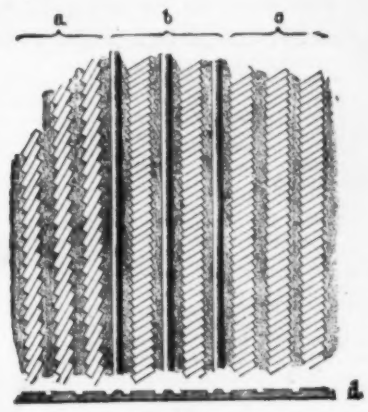


FIG. 2.



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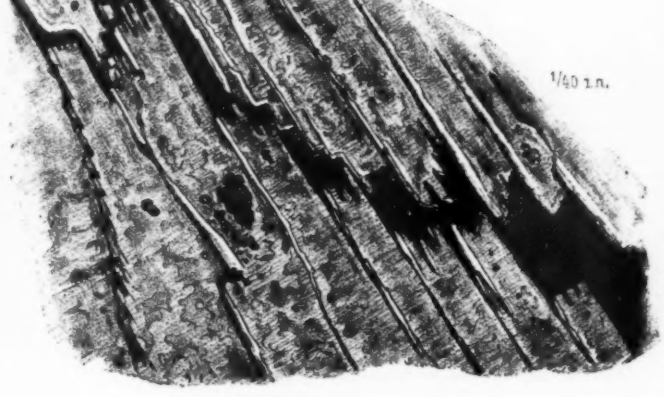
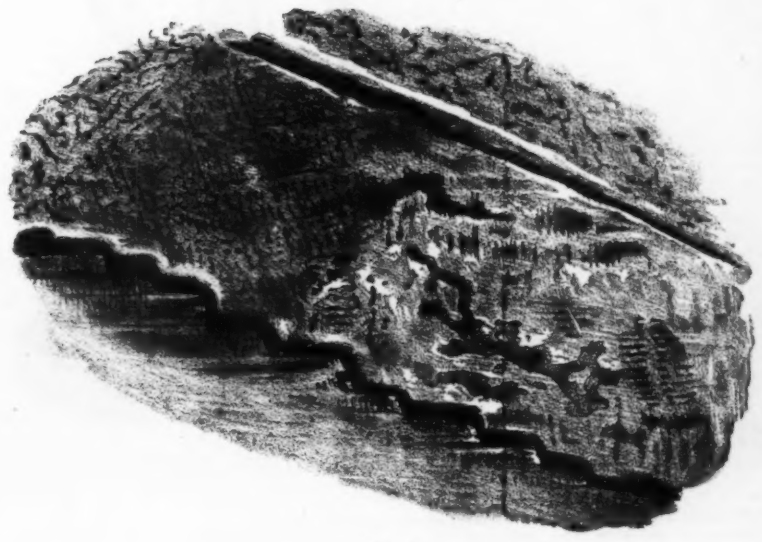


FIG. 5.



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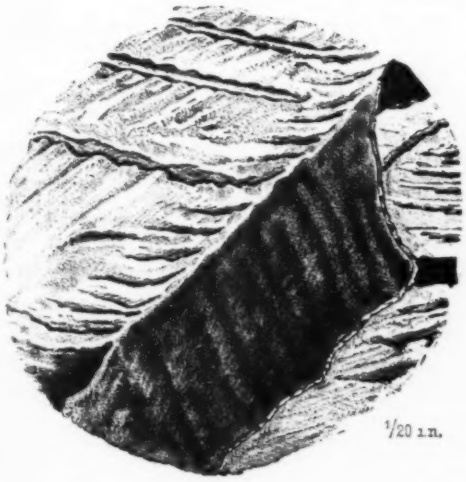
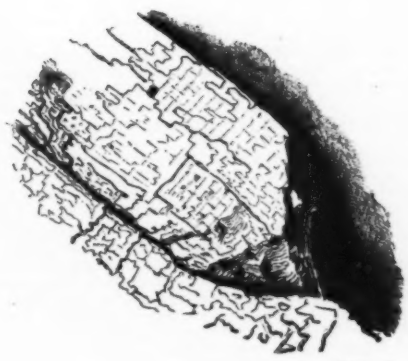


FIG. 4.



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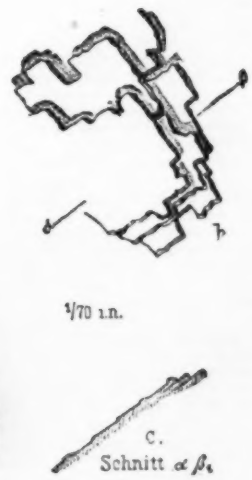
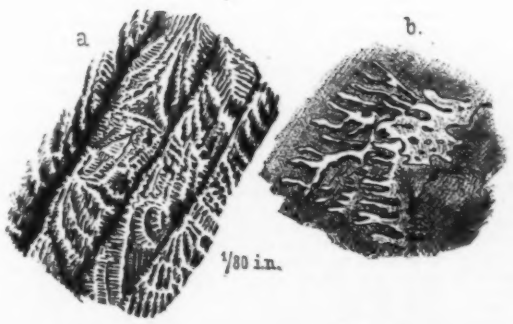


FIG. 10.



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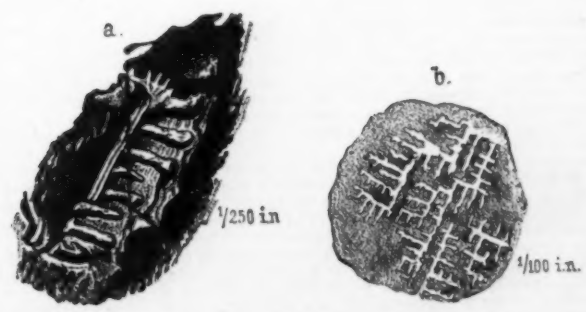

FIG. 9.

THE STRUCTURE OF ORES AS REVEALED BY THE MICROSCOPE.

THE HENZE-ELLENBERGER HIGH PRESSURE SACCHARIFIER.

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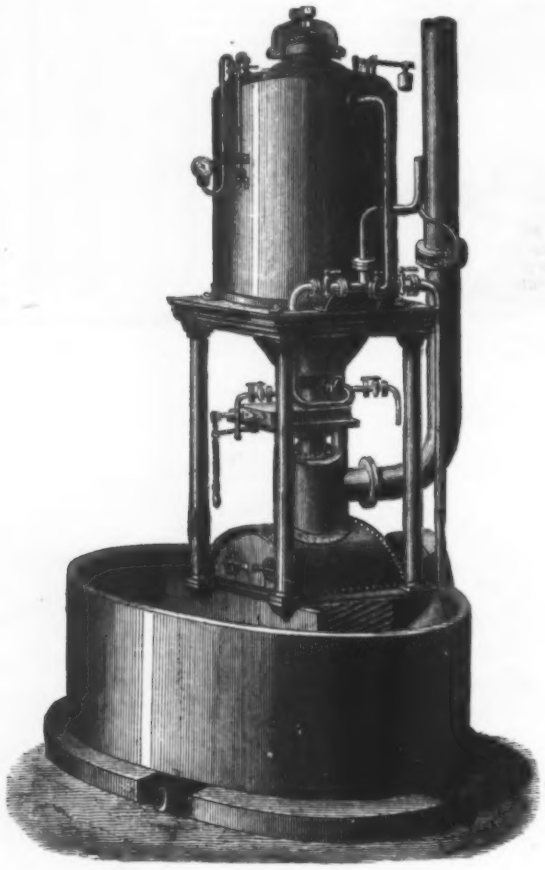


THE HENZE-ELLENBERGER HIGH PRESSURE SACCHARIFIER.

combined with an Ellenberger mill, constructed by Mr. Henze, and enjoying much popularity among Austrian and Hungarian distillers.

It consists of a cylindrical boiler with a funnel-shaped bottom, into which the material is introduced through a manhole provided at the top. The grain or potatoes are previously mixed with about three times their weight of water. It must be remarked that the practice of soaking the material in lukewarm water for any length of time previous to the introduction into the apparatus ought to be discarded, as it causes the formation of lactic acid, and consequently injures the alcohol obtained both qualitatively and quantitatively.

The boiler is tested to a pressure of eight atmospheres, but less than four atmospheres is generally required for the operation. The apparatus is also provided with a safety valve, which opens when the pressure approaches five atmospheres.

Steam is introduced into the boiler through the bottom in such a manner that all the portions of the contents are constantly kept in motion during the entire operation. When steam is admitted into the boiler, the air is allowed to escape through a valve. As long as the latter is kept open, the water condensed within the boiler is also allowed to run off. As soon as all the air has been forced out of the boiler, all valves are closed. The material is now for three or four hours exposed to the combined action of heat and pressure. Samples may be taken from time to time from a place provided for that purpose. At the end of that time the liquid is of a dark yellow color, and the starch has been completely converted into sugar, although the grains on the pieces of potato retain yet their original shape. Care must be taken to introduce the steam slowly, and to regulate the pressure properly, as a portion of the sugar will otherwise be converted into caramel and rendered unfit for the formation of alcohol.

When the operation is finished, the mash is blown out, under pressure, into the mill, which has meanwhile been started. Hereby the solid particles are completely crushed, and the mash forms now a thin paste, possessing all the qualities necessary for the formation of alcohol, which now begins.—*Zeitschrift für Oesterr. Spiritus-Industrie.*

CARTRIDGE MANUFACTURE.

THE copper rimfire cartridge was to the perfector of modern firearms what cheap paper was to printing, the one necessity to secure success, for until its advent the breech-loading pistol, rifle, or gun, was, at the best, a cumbersome and inefficient weapon, especially costly of manufacture, and ever liable to leak fire at the joints, a fault which no breech-loading firearm, not provided with a metallic cartridge, has ever been free from.

The substitution of metallic envelopes for paper in cartridges, as in the Maynard, Burnside, and other similar fire-arms, overcame this tendency, although the use of caps, or the patent primers, which too often failed in actual use, was still in the way of reliable and rapid discharges. The perfection of a copper cartridge, water-tight, containing its own detonating compound, and affording a gas-tight expanding joint at the breech, has rendered possible the production of such weapons as the world has never seen, in point of accuracy, certainty, and rapid firing, and general beauty and elegance, combined with a cheapness of cost before undreamed of.

As a result we see our armories supplying many foreign nations with rifles, revolvers, and Gatling guns, cheaper and better than the boasted workshops of England, Belgium, and Germany can supply, and revolvers are sold at prices so low that a seven-shooter actually costs less in a retail store in Boston than the wholesale list price of a pair of the cheapest pocket pistols made in Birmingham, while small single-barreled weapons, rifled, sighted, and nickel-plated, and costing less than a dollar each, are really as accurate as the best dueling pistols of forty years ago.

A visit to the works of the United States Cartridge Company, at Lowell, Mass., recently, afforded us much pleasure, and as we, who in our poor way have done something with rifle and pistol, found much to admire and wonder at, we propose to trace, for the benefit of our readers, the train of processes which produce a common rimfire cartridge.

The works themselves are situated on the east of the "bunting factory," of which all have heard, and on entering the office one finds himself in front of the usual grating which, in such establishments, barricades the clerks from the intrusion of unwelcome visitors. We, however, are privileged, at least for this present occasion, and as we go in we stop a moment to examine a rack in which are a score or more of rifles, and as many pistols, of different makes, caliber, and uses, among which we notice the Russian, Turkish, Peabody, Henry, Maynard, Sharp, Ballard, Remington, Wesson, Forehand & Wadsworth, Colt, and other popular makes, for all of which the United States Cartridge Company make rim and central fire cartridges, cases, and primers to suit.

The treasurer, Mr. Paul Butler, has just come in from a journey from Washington, but after a pleasant greeting, dives into a mass of correspondence, plans and specifications, and we take the opportunity to look around us. The apartment is large, but simply furnished, and on a bench with vise and tool-rack are many samples and varieties of cartridge manufacture, sample cards of Eley's and other foreign makes of fixed ammunition hang on the wall, a large glass case holds another lot of guns and rifles, and a small library of patent office and ordnance reports bear the marks of repeated use. Mr. Butler at last finishes his business for the time, and leads us into the adjoining factory.

Here in the storeroom are piled the rolls of brass and copper tape from which the future cartridge is to be formed, and these, like carpet binding, are brought to the factory in coils of from thirty to one hundred feet long, and of varying thickness and width, according to the caliber and length of case required.

Next, in the stamping room, are many machines which by means of dies cut out from each tape round blanks, which are by a punch at the same motion formed into a shallow cup, like a very thick and short percussion cap. These cups are carried into the annealing room, where by heating and cooling they regain the toughness and ductility lost in the first operation. After which, in machines presided over by girls, they are forced through a still smaller aperture than before, and the tube increased in length and diminished in thickness by a process analogous to wire drawing.

The number of successive annealings and drawings increases with the length of the cartridge case and the hardness of the metal used, but at the end we have a metal tube, shaped like a test tube, closed at one end, where like the breech of a Rodman gun it is much the thickest, and with the open end ragged and broken and far too long for its destined use.

This latter defect, however, is soon overcome by a little machine which takes the tubes on a steel mandrel, revolves them between a pair of cutting jaws, and cuts them to a uniform length; after which another machine flattens the closed end of the tubes and leaves the rim, between whose metallic surfaces the priming composition is to be placed. We will suppose that these are of the smallest and most popular size, such as is used for seven-shot revolvers (No. 22), and follow them through the remaining processes.

The tubes are now ready to be primed, and here if one is at all nervous and conversant with the terrible power of the fulminate of mercury employed for that purpose, and its extreme sensibility to friction when dry, he is apt to feel a little shocked at the apparently careless and rapid manner in which this part of the work progresses. At a huge table covered with sheets of rubber sit the girls employed, each having a bowl partially filled with the detonating mixture beside her, and a druggist's spatula with a bowl of water at hand. An iron plate, containing one hundred small holes, rests on a smooth surface; a handful of fulminate is scattered over this, and pressed into little wafers with the previously wet spatula, and then the plate is placed in position over another containing as many empty cases.

By an equal number of revolving spindles the pellets of composition are driven down into the tubes and swept between the folds of the rim, and after drying the cases are all ready for filling. This dangerous process is, of course, well guarded against by the use of very wet fulminate and the free use of wet swabs on the floor around the table; but in spite of all care on the part of those in charge accidents do occur, although thus far without fatal results.

The bullets used are made of the best and purest lead, and generally without alloy, being cast in moulds holding from fifty to one hundred slugs, according to size, the halves of the mould sliding on a metal plate, and being opened or closed by a handle with powerful leverage. A third piece on top has a gutter, with holes communicating with each cavity, and the metal around each is beveled to a cutting edge. The operator swings to his mould, brings the top into position, pours a ladleful of lead into the mould, with a lever cuts the neck of the castings nearly off, and then the workman, placing the bullets between two parallel bars, wrenches them off with a dexterous turn of the wrist, and they fall rattling into a bin below. When cool they go to the swedging machines, which in the case of the smaller bullets compress them into shape at one operation, throwing off the superfluous metal in the shape of a slender wire. The larger bullets, however, are first swedged into the shape of a cylindrical roll with convex ends, losing in this process the overplus of lead as before described, and a second process of swedging is needed to give the shape and raise the ring of belts around the base of the missile.

At a counter on one side of a high board screen stands the loader, and on the other side are several small girls who rapidly fill with primed cases iron plates pierced for a hundred cases, and others with as many bullets. The loader opens his powder chest, fills the cases with a practiced sweep, brushes off the surplus powder, closes the chest, and taking the plates to a powerful press, puts them in position and forces the bullets into place.

Another machine fastens the bullets by tightly creasing the edge of the copper into the lead, and then the cartridges go to a young lady, who arranges them deftly, by fifties or hundreds, in a perforated plate with a wooden handle. Opposite her another operative presides over a bath of melted tallow, wax, and other lubricants, and with a practiced touch dips the bullets into the mixture, removing the surplus fat by touching their points on a heated plate. By her side are baskets of paper boxes and lids, and the finished cartridges go, when cool, into these receptacles, and are sealed and labeled by other girls.

As we have seen, the smallest cartridge goes through seventeen or eighteen hands, and almost as many machines, in the process of manufacture; but so perfect is the machinery, and so rapidly is the work carried on, that, even with a comparatively small force employed, the production of No. 22, the popular pistol size, is 100,000 per day. Certain of the larger sizes, however, require more careful handling; and the large belted balls are lubricated by a special machine, which fills the grooves between the belts with a rim of paraffine or some similar lubricant. The loading of some cartridges is also done by a machine to which a closed hopper of powder is attached, which puts a case in position, measures and pours in the proper charge, and places and drives down the bullet, crimping the end of the shell around it.

But nearly all the long-range and army ammunition now made is in the shape of central-fire cartridges, discharged by primers or short caps which fit into a circular pocket at the rear of the cartridge. These primers are composed of two parts, the cap and the anvil; the latter being a metallic disk which furnishes a means of firing the percussion powder, and allowing the fire to reach the powder by passing through holes or slits drilled through or stamped out of its circumference.

While copper, on account of its toughness, is the favorite metal for rimfire cartridges, alloys of copper and zinc are preferred for central fire cases, which, as being intended for repeated use, are thicker, heavier, and of corresponding cost. They are also considered safer for large calibered rifles, in which the rimfire cartridge may sometimes split, to the damage of the soldier or sportsman holding it.

Most of these cartridges, especially those for army and long range rifles, are "choked" at the bullet end to the caliber of the missile, which is about one-twentieth less in diameter than the powder chamber of the cartridge. This principle, which is supposed to secure more complete combustion and consequently greater force, has of late been applied by the Italian government to some monstrous ordnance, with wonderful results as to penetration and power.

The bullets for most long-range rifles are extra long, some of those in use being four diameters in length. A shallow cup-like cavity in the rear intended to fill the grooves by expansion, and a paper covering, which, with the lubricating material used, serves to keep the cartridge water-tight, are the principal characteristics of the bullets used in this kind of ammunition. Such shells seldom burst, and can be recapped and reloaded many times, which cannot be done in the field with the rimfire cartridge.—*Boston Journal of Commerce.*

THE UNCONSIDERED USES OF TIMBER.

IT is usual to refer to the consumption of wood to such causes as the demand for it for building and engineering purposes, and also such minor ones as the lucifer match and road-making industries make. It is true that these are the principal means by which wood is consumed in these and other countries; but there are countless other ways which go to swell the sum-total in no insignificant degree, and yet which are left in comparative security, for few persons think of them. As, for instance, in America tulip wood is much used for wooden bowls, and for the heads of hair brooms or sweeping brushes, for eating and drinking troughs of cattle, and no inconsiderable portion furnishes wood for Indian canoes. One of the principal uses of the

wood of the holly, dyed black, is to be substituted for ebony in the handles of metal teapots, etc., and the strong, straight shoals, deprived of their bark, are made into whip-handles and walking-sticks. The lime tree forms the best planks for shoemakers and glovers, upon which to cut their leather, and is extensively used in the manufacture of toys and Tunbridge ware, and by the turner for pill boxes, etc.; and the inner bark is made into ropes and matting. The sycamore furnishes wood for cheese and cider presses, mangles, etc.; and when the wooden dishes and spoons were in common use they were mostly made of this wood. It is used now also in printing and bleaching works, for beetling beams, and in cast iron foundries for making patterns. The yew is used by the turner, and made into vases, snuff boxes, and musical instruments; and it is a common saying among the inhabitants of New Forest that "a post of yew will outlast a post of iron." Where it is found in sufficient quantities to be employed for works underground, such as water pipes, pumps, etc., the yew will last longer than any other wood. Gate posts and stakes of yew are admirable wear, and in France the wood makes the strongest of all wooden axletrees. Of the beech are made planes, screws, wooden shovels; and common fowling-pieces and muskets are also stocked with it, and beech staves for herring barrels are not unknown. The sweet or Spanish chestnut furnishes gate and other posts, railing, and barrel staves, hop poles, and other such matters, such as strong and good charcoal, though scarcely equal to that of oak for domestic purposes, but considered superior to that of any other for forges, for which purpose it is much used in Spain, and also in Switzerland. Horn beam is the best wood that can be used for cogs of wheels, excelling either the crab or the yew; but its application in this manner is about at an end. As a fuel it stands in the highest rank, emitting much heat, burning long, and with a bright clear flame. In charcoal it is also highly prized, not only for culinary purposes and the forge, but also for the manufacture of gunpowder, into which, on the Continent, it enters in large proportion. In Russia, many of the roads are formed of the trunks of the Scotch pine, trees from six inches to a foot in diameter at the larger end being selected for the purpose. These are laid down side by side across the intended road, the thick of one alternately with the narrow end of the other, and the branches being left at the end to form a sort of hedge on each side of the road. When thus laid, the hollows are filled up with earth, and the road is finished, being analogous to the corduroy roads of North America. In Germany casks are made of larch, which is almost indestructible, and they allow of no evaporation of the spirituous particles of the wine contained in them. In Switzerland, it is much used for vine props, which are never taken up, and which see crop after crop of vines spring up, bear their fruit, and perish at their feet, without showing symptoms of decay. The uninjured state in which it remains when buried in the earth or immersed in water renders it an excellent material for water pipes, to which purpose it is largely applied in many parts of France. The butternut is esteemed for the posts and rails of rural fences in America, for troughs for the use of cattle, for corn shovels, and wooden dishes. Shellbark hickory provides baskets, whip handles, and the backbows of Windsor chairs. The pignut hickory is preferred to any other for axletrees and axe handles. The sugar maple is used by wheelwrights for axletrees and spokes, and for lining the runners of common sleds. Dogwood is used for the handles of light tools, such as mallets, small vises, etc. In the country it furnishes harrow teeth to the American farmer, and supplies the harness of horses' collars, etc.; also lining for the runners of sledges. The mountain laurel is selected for the handles of light tools, for small screws, boxes, etc. It most resembles boxwood, and is most proper to supply its place. Bowls and trays are made of red birch, and when saplings of hickory or white oak are not to be found, hoops, particularly those of rice casks, are made of the young stocks and of branches not exceeding one inch in diameter. Its twigs are exclusively chosen for the brooms with which the streets and courtyards are swept. The twigs of the other species of birch, being less supple and more brittle, are not proper for this use. Shoe lasts are made from black birch, but they are less esteemed than those of beech. Immense quantities of wooden shoes are made in France from the wood of the common European alder, which are seasoned by fire before they are sold. The wood of the locust is substituted for box by the turners in many species of light work, such as salt cellars, sugar bowls, candlesticks, spoons and forks for salads, boxes, and many other trifling objects, which are carefully wrought into pleasant shapes and sold at low prices. The olive is used to form light ornamental articles, such as dressing cases, tobacco boxes, etc. The wood of the roots, which is more agreeably marbled, is preferred, and for inlaying it is invaluable. Of persimmon turners make large screws, and tinmen mallets. Also shoemakers' lasts are made of it equal to beech, and for the shaft of chaises it has been found preferable to ash, and to every species of wood except lancewood. The common European elm is used for the carriages of cannon, and for the gunwale, the blocks, etc., of ships. It is everywhere preferred by wheelwrights for the naves and fellies of wheels, and for other objects. White cedar serves many subsidiary purposes. From it are fabricated pails, washtubs, and churns of different forms. The ware is cheap, light, and neatly made, and instead of becoming dull, like that of other wood, it grows whiter and smoother by use. The hoops are made of young cedars stripped of the bark and split into two parts. The wood also supplies good charcoal. The red cedar furnishes staves, stop cocks, stakes, and is also used for coffins.

A few others may be briefly named, separating into trades as follows, applying to the American manufacture:

Sieves, usually of black or water ash for the bottom and oak or hickory for the circle; whipstocks, white oak; baskets, willow, white oak, and shellbark hickory; picture frames, white pine, and sweet gum; saddletrees, red maple and sugar maple; screws of bookbinders' presses, hickory and dogwood; hatters' blocks, sour gum; corn shovels, butternut; shoe lasts, beech, and black or yellow birch, etc.

This slight sketch, which is by no means complete, will serve to give an idea of some of the ways in which timber is consumed, besides being wasted and put to its legitimate purposes in other manners. The items may seem beneath notice, but the aggregate must be something important.—*London (Eng.) Timber Trades Journal.*

COLLOTYPES ON ZINC PLATES.

By Prof. J. HUSNIK.*

THE first attempts in the collotype process were made on metal plates, and the adhesion of the film was generally effected by the oxidation of the metallic surface. Since Albert introduced the use of glass plates, that of metal as a support for the colloid films has been entirely neglected, for it was not possible to obtain such even and firm films on metal plates as on plane polished glass plates. Obernetter has succeeded in overcoming the difficulties that attended the uneven surface of metal plates, and has for some time practiced a system of collotype in which he uses, as supports, zinc plates as thin as paper. Although he himself now also lays the chromated gelatine film on a glass plate, his former method is found to be of very great efficiency, and it is employed with advantage not only by Albert himself—more especially in his large size pictures—but also by several other houses. Such thin plates of zinc are used for glazing printing paper, and are found in the market with a perfectly even and almost perfectly polished surface. This circumstance considerably facilitates the manipulation, for it is only necessary to clear off with emery paper any grease or dirt that may happen to be on the plate, when the preparation can at once be proceeded with.

First Preparation of the Zinc Plate.—When the plate has been rubbed down as above described, it must be dusted with a short brush, and then once or twice washed first with pure water, and then with a three per cent. solution of chromic acid. The acid forms, with the metal of the plate, zinc chromate, which remains as a yellow coat attached to the surface, and this causes the perfect adhesion of the gelatine to the metal. After the solution of chromic acid has been allowed to drain off for some minutes, the plate, while still wet, is rinsed several times with pure water, and, when thus thoroughly moistened, it is coated with a filtered solution of one part gelatine in twenty parts water mixed with four parts spirit. The plate must now be held over a hot stove plate, or over a flame, in order to prevent the gelatine from setting too rapidly, and so that the solution may be distributed as evenly as possible. Afterwards the solution is drained off, and dried in a drying oven. Obernetter and Albert allow the zinc plates to dry in a horizontal position at a temperature of from 35° to 45° R.

My own experience is, that better results and more even films are obtained by suspending the plate at the center over a square stick placed horizontally, the ends hanging down on each side somewhat in the form of an arch, and allowing it to dry in that position. It is true that the film will flow for a few seconds longer from the top of the arch towards the ends; but if the temperature of the oven be kept at from 50° to 55° R., the upper part of the plate will dry quicker than the lower, and this unequal drying will adjust the evenness of the film, so that it possesses everywhere the same thickness. For this first preparation, however, the position of the plate during drying is of no importance, as only a thin film is left on it; of so much the greater consequence is it in the succeeding operation.

Second Preparation.—The first film is not in the least degree sensitive to light, for no chromic salt was added to the gelatine; its object is to produce adhesion between the chromated gelatine film and the zinc plate. It would be quite possible to mix the first layer of gelatine with the chromic salts, and to produce it at once of the required thickness; but the results obtained are in every way better when the films are employed. The first layer is tanned by means of the zinc chromate and the other products of the decomposition—chromium chromate, for instance—and this tanning action penetrates the entire thickness of the film, causing dark spots in the prints; but a second layer combines with the first, so that both adhere firmly, and irreproachable prints are produced.

For the second layer, a hot solution of 100 parts in gelatine in 1,600 parts water must be prepared, and mixed with 20 to 25 parts of some bichromate salt (ammonium bichromate is most sensitive) and one part chrome-alum; the latter substance must only be added slowly, or it will cause coagulation. The zinc plate is now placed on a horizontal table with the already prepared surface uppermost, and the solution is poured on it, and spread over it briskly with a brush; more solution is again poured on and rapidly drained off, so that all bubbles may be removed. After the greater part is thus drained off, the plate is hung up in the form of a bow in the drying oven at a temperature which must not exceed 45° R., nor fall below 35° R. Albert and Obernetter, before drying the film, warm it slightly, and then lay the plate on the top of a flat vessel covered with a horizontal metal sheet; ice-cold water is made to flow through this vessel, which keeps the metal cover cold. In this position the gelatine sets evenly before it has time to run into the depressions of the plate: the plate is then dried in the oven at a temperature of from 40° to 45° R. As the first layer absorbs a portion of the water, the second layer is no longer liquid at the above-mentioned temperature, and dries very evenly. For my own part, however, I prefer drying by suspension, as I have already described.

When the second preparation is completed and the film thoroughly dried, the plate is exposed under a negative in the same way as an ordinary glass plate. The process of exposure is much facilitated by the zinc plate being so thin that it can be accurately pressed on to any kind of negative, whether it has a plane or a curved surface. In copying also, just as in printing on paper, the plate can be raised and bent over so as to give an opportunity for examining how the action is proceeding. So soon as the half-tones make their appearance, the exposure must be interrupted, and the plate developed with water.

When a print is to be taken from the plate, the latter must be carefully wiped on both sides, and more especially on the reverse, so that no grain of sand or dust remains adhering to it, for any such impurity will, in the press, be driven into the zinc, so that it cannot be used a second time A perfectly clean lithographic stone is now coated with thick lithographer's varnish, the reverse side of the plate laid on it, and the whole pulled in the press; the plate will then adhere to the stone, and form a support for it. We are now in a position to proceed to inking the plate and taking a print from it. The rollers best adapted for collotype printing are those found at the establishmeut of Romaine Talbot, 68 August Strasse, Berlin. They are small glue rollers with only one handle; they do not tire the printer, and allow the work to be proceeded with rapidly.

Films prepared by this method possess extraordinary durability; the plates are only worn out after very long use in the press, when the upper surface of the film begins to deteriorate. The low price of the materials employed permits of large plates being produced very cheaply, and there is no occasion to fear their cracking as with glass plates. If great care has been taken in printing, the zinc plate can be used again; it is only necessary to dissolve off the gelatine in a hot solution of alkali, and to rub down the plate afresh with emery paper. Albert has produced collotypes, by this method, a meter and more in length; the copy of the picture "Lohengrin's Farewell," was printed for the Art Society of Vienna from zinc plates only.

By the side, however, of the advantages that this process possesses over that with glass plates, it has one prominent defect: it sometimes happens that after the plate has been printed from continuously for four or five days small spots of oxide make their appearance, and the films become altered so that in these spots too much ink is taken up. Before printing, therefore, the plate must be carefully gone over, and those spots where they occur in the light parts must be carefully wiped away. On this account it becomes necessary to use up the plate as quickly as possible, and to keep it perfectly dry while not in use, for in a dry state the alteration will not take place.

For moistening the plate, I recommend the well-known mixture of glycerine, water, common salt, and ammonia, and to employ it in a concentrated form; when the plate is once moistened with this mixture ten to fifteen prints may be taken from it, and the time that is usually occupied in wetting the plate after every pull can in this way be saved.

With thicker films even fifty to eighty prints may be taken without a fresh moistening, but such films have not so fine a grain, and are liable to tearing.

On the other hand, this process affords the means of working with a quick running press and endless paper, for the printing plate can be bent round and fastened to the cylinder. The inking and moistening can be effected by several rollers on one side of the cylinder, while the printing takes place on the other side, when the endless paper comes into contact with the film. Albert has long ago come to the determination to have machines of this kind constructed, but is waiting until he can quite get rid of the spots of oxide which so often make their appearance. There certainly are means for, at any rate, weakening the effect of these spots, but none, so far as I know, that will quite get rid of them.

The addition of chrome-alum, as I have above recommended, has a considerable influence in this direction, and so has the moistening with the solution of glycerine and ammonia. If each spot be stippled with a fine brush dipped in a concentrated solution of ammonium oxalate, the spots will vanish for a time, but return again the next day, when they must be again treated in the same manner.

* *Photographisches Wochenblatt.*

NEW FILTERING APPARATUS.

FOR the purpose of filtering turbid liquids, which it is desired to keep from contact of the air, particularly such as wines and fermentable fluids, the apparatus described in the following will be found of great service.

A flask or bottle, with rather wide neck, is fitted with a cork through which two glass tubes are passed, one of which projects a distance below the cork, and the free end of which passes through another smaller cork, while the other tube only just reaches to the lower surface (see cut). A linen bag, made by sewing a strip of linen 1½–3 feet long and 2¼–3¼ inches wide, is slipped with one end over the small cork at the end of the longer tube, and tied; the other end of the bag is either sewed up or closed by tying with a string. Previously, however, the bag is wetted with the liquid to be filtered, and partly filled with some of the turbid liquid mixed with coarse animal charcoal. It is then introduced into the flask, and the latter corked, as shown in the cut. By connecting the vessel containing the turbid liquid with the bottle and filtering bag, by means of the flexible rubber tube, the liquid to be filtered flows by its own pressure into the bag, and is forced through its pores into the flask, whence it flows through the shorter tube into the receiver placed at a lower level. The cork used for closing the flask should be very sound; a rubber stopper is, perhaps, preferable. There are several advantages connected with this apparatus. In the first place, the flow of liquid may be retarded or accelerated by using longer bags and placing the flask at a lower level. The flow may be at any moment suspended or again started by the compression or release of a pinchcock applied to the exit-tube. Finally, the filtering bags are easily cleaned, and there is scarcely any loss. Should any particular liquid be found not to pass clear through a single bag, a second bag may be slipped over the first, which will generally overcome this difficulty.—*Die Weinlaube.*

FILTERING APPARATUS.

A NEW FAST GREEN AND MALACHITE GREEN.

By Messrs. BINDSCHEDLER and BUSCH.

UP to the present the so-called methyl-green has been obtained from dimethyl-aniline by converting the latter into violet by oxidation, and then the violet again by methylation into green.

It has long been the endeavor of the manufacturers of aniline colors to get the green direct from dimethyl-aniline without going through the violet; and taking as a starting-point the theoretical and meritorious studies of Prof. A. Baeyer, Otto Fischer, in Munich, and Oscar Doebner in Berlin, it has been found possible to produce green direct from dimethyl-aniline, and even at a very low price.

These direct greens are brought into the market under the

names of new fast green, malachite green, etc., and possess about the same chemical qualities, but the mode of manufacture and the attention paid to the same cause more or less a difference in brilliancy of shade and yielding. It is, however, very easy to distinguish direct greens from methyl-greens through the simple fact that wool, silk, or cotton, when dyed with direct greens, can stand a very high degree of heat without the green color turning into violet; while stuff dyed with methyl-greens turns violet when brought into contact with an iron exceeding 120° of heat.

The aforesaid theoretical mode of Otto Fischer, in Munich, was published in the reports of the Berlin Chemical Society on August 11, 1877, under the title of "Condensations Producte Tertiärer Aromatischer Basen." Otto Fischer describes therein a new base, which he obtains by the reaction of dimethyl-aniline, chloride of zinc, and hydride of benzyl, and further states that oxidizing the salts derived from his method led to the production of a beautiful bluish green color.

The exceedingly high price of the hydride of benzyl has hitherto prevented the practical application of Fischer's most interesting discovery. Now, however, this material is produced at a price which renders its practical use quite possible.

The process of manufacturing malachite-green is based upon the theoretical studies of Oscar Doebner, published in the reports of the Berlin Chemical Society, May 27, 1878.

Doebner proves in his report that green can be obtained direct from dimethyl-aniline, chloride of zinc, and trichloride of benzol.

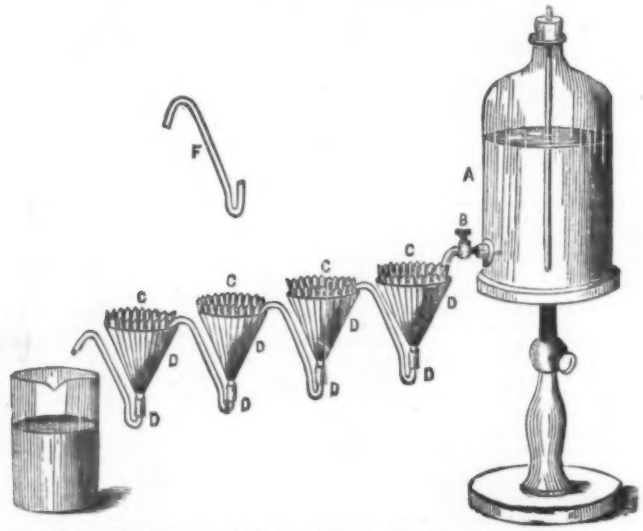
Besides the before-mentioned system of producing direct greens through the medium of hydride of benzyl, there are other methods by which the same can be obtained: for instance, the product of the reaction of dimethyl-aniline, chloride of zinc, and dichloride of benzoyl, submitted to oxidation, gives a very beautiful and cheap green.

From the preceding statement it is obvious that different methods of manufacturing direct green exist.—*Chem. News.*

APPARATUS FOR CONTINUAL DIALYSIS.

THE apparatus hitherto in use for dialysis usually consisted of drum-shaped vessels floating upon distilled water, or of a series of perpendicular membranous septa contained in a trough, each alternate compartment of which is charged with distilled water. With a view of diminishing the amount of distilled water required and increasing the extent of dialyzing surface, Mr. Eug. Lebaigue has devised a new form of apparatus, which is here illustrated.

The apparatus consists of a large flask, A, with faucet, B,



APPARATUS FOR CONTINUAL DIALYSIS.

at the bottom, full of distilled water; a series of glass funnels, D, to the short neck of which is attached, by rubber-tubing, the curved siphon, which is separately figured in F; and finally a receiving vessel, E. Each funnel is provided with a plaited filter made of parchment paper, and projecting 3/4 to 7/8 inch above the edge of the funnel. This is necessitated by the increase of volume of the contents of the filters. The first filter is now charged with solution of chloride of iron (ferric oxychloride) to about three-fourths of its depth. Distilled water is then poured into the funnel and allowed to remain in contact with the filter for twelve hours. Then the second filter is charged in the same manner and the faucet of the flask carefully opened, when the water of the first funnel will be gradually forced over into the second, and will be replaced by fresh distilled water. After 12 hours, another funnel with filter is connected with the series, and this is continued with as many filters as is desired. The rate at which the distilled water is allowed to pass is controlled by its dropping from the last siphon-tube.

Whenever the contents of the first funnel cease to have an acid reaction, and to be precipitated by silver nitrate, they are withdrawn, the second filter is made the first, and a new funnel with filter inserted at the end.

The proportions which Mr. Lebaigue has adopted for making dialyzed iron are the following:

Water of ammonia, sp. gr. 920	400 parts.
Distilled water	400 "
Solution of ferric chloride, sp. gr. 1,260	1,000 "

Mix the distilled water and ammonia, and add the mixture gradually to the solution of ferric chloride, under constant stirring, until a clear mixture results.

Experience having shown that among crystalloids, the chloride of sodium dialyzes best, Mr. Lebaigue thinks it would perhaps be an advantage to replace the ammonia by soda, or sodium carbonate.—*Journ. de Pharm. et de Chim.*

CHROMIUM AND ITS COMPOUNDS.

As compounds of chrome are so very extensively used in dyeing, printing, color-making, etc., and as there seems to be some difference of opinion, or misunderstanding, among our correspondents on the nature and composition of these compounds, it may not be useless if we give a survey of these substances.

The root or foundation of the whole group is a metal, which, as such, plays no part in tinctorial chemistry at all. It combines with oxygen in equal equivalents to form a compound known under the following names: Protoxide of chrome, or of chromium, chromous oxide, or monoxide of chrome, or of chromium. This substance is exceedingly unstable in its nature, and on exposure to water or moist air it takes up more oxygen, and passes into the compound next following. Hence it is not a commercial article, and has not been introduced into the arts and manufactures. Its solutions and the corresponding chlorine compound (chromous chloride, or protochloride of chrome) are blue.

A much more important and useful body is the next compound, known as chromic oxide, oxide of chromium or of chrome, chromic sesquioxide, sesquioxide of chrome or of chromium. This substance consists of two equivalents of the metal chromium, combined with three of oxygen, and may be obtained by mixing 240 parts of bichromate of potash, perfectly dry, 48 parts of gunpowder, and 5 parts of dry sal ammoniac, making the whole into a compact heap, and setting in on fire. It smoulders away, and on washing the residue with water, chromic oxide is left as a green powder. In this state it is scarcely acted on by acids, with the exception of boiling oil of vitriol. But it may be obtained in a different form by dissolving bichromate of potash in water, adding muriatic acid and alcohol, or sugar, and boiling till the red color of the liquid is turned to a green. If some ammonia is then added to the solution, a greenish-gray precipitate is formed, which is hydrated chromic oxide, or, as it is now often called, chromic hydroxide. In this state it is readily soluble in acids, forming green or violet-gray solutions of the salts of chromic oxide. These compounds are known as sulphate of chrome, nitrate of chrome, muriate of chrome, etc., and must be carefully distinguished from the compounds of chromic acid, to which we shall presently come. In all these compounds the chrome plays the part of a base, just as does, for instance, the iron in nitrate of iron, or the alumina in cake alum. If we take cake alum and imagine the alumina taken away, and an equivalent quantity of sesquioxide of chrome put in its stead, we have the exact composition of sulphate of chrome, or chromic sulphate. These salts of chrome—green or violet, it must be remembered, when in solution—have no great disposition to part with oxygen to organic bodies or other matter with which they come in contact. They are not of very wide use, with the single exception of one of them, which is sometimes formed as a secondary product when a mixture of chromate of potash and sulphuric acid is used for oxidizing certain organic matters. We mean chrome alum, which is a compound of sulphate of chrome with sulpoate of potash. In fact, if we take common crystallized alum and suppose all the alumina removed from it, and chromic oxide put in its place, we have the composition of chrome alum. It may seem strange that a substance should bear the name of "alum" which does not contain a particle of alumina; but we must remember that the term "alum" has now become the name of a whole class of compounds, of which common alum is merely the type. Thus we have iron alum, in which the place of the alumina is filled by the sesquioxide of iron.

A still more highly oxidized compound of chromium, and one more generally useful, is the teroxide of chromium, chromic anhydride, or chromic acid, which consists of one equivalent of chromium combined with three of oxygen. This acid and all its compounds, whether soluble or insoluble, are no longer green or violet, but yellow, orange, or a red approaching to scarlet. They very readily give off a portion of their oxygen to organic matter, and thereby become reduced generally to chromic oxide. Chromic acid forms combinations not with acids, but with bases, the compounds thus arising being named chromates, and being similar in their composition to sulphates, save that they contain chromic acid in place of sulphuric acid. Just as we have sulphates and bisulphates of potash, soda, etc., so we have chromates and bichromates of the same bases, the latter containing twice as much chromic acid as the former. Chromic acid by itself, or merely dissolved in water, is not an article of commerce on the large scale. But substantially it is produced whenever chromate or bichromate of potash dissolved in water is mixed with sulphuric acid. Its two most common combinations have a variety of names, which at times causes no little confusion. If one equivalent of potash is combined with one equivalent of chromic acid, we have a lemon-yellow salt, which rejoices in the names of yellow chrome, chromate of potash, chromate of potassa, chromate of potassium, yellow chromate of potash, potassic chromate, potassic monochromate, or simply chrome. This compound is much less used in England than on the Continent, where its action is considered as being gentler and more easily regulated than that of the next following compound. If instead of one equivalent of chromic acid two equivalents are combined with the potash, the result is named chrome, red chrome, bichrome, red chromate of potash, bichromate of potash, potassic bichromate, potassium bichromate, and potassium dichromate, the worst feature in the medley being that both this and the foregoing compound are by some persons named chrome.

We see, therefore, that in its combinations with the alkalies potash and soda, chromic acid forms soluble compounds which, as the proportion of the acid increases, pass from yellow to red. With the true metallic oxides, such as lead, chromic acid forms insoluble compounds, and here the smaller proportion of acid gives the redder shade. The chromates of lead, etc., are little used in the tinctorial arts, save in certain pigment styles. But here, again, there is scope for confusion of names. The yellow chromate of lead is very generally called "chrome yellow," and the red subchromates of lead "chrome red," which are easily mistaken for the "yellow chrome" and "red chrome" mentioned above.—*Chemical Review.*

RESEARCHES ON OZONE AND THE ELECTRIC EFFLUVE.

By M. BERTHELOT.

HYDROGEN and oxygen mixed in the proportions of two vols. of the former to one of the latter, do not combine under the influence of the effluve, whether in sealed concentric glass tubes or in a tube surrounded with a lamellar spiral of platinum and placed over mercury. The tension of these experiments was about equal to that which gives sparks of seven to eight centimeters in length through air when operating with an induction coil fitted with condensers. Doubtless on increasing the tensions progressively nearly up to those which produce disruptive discharges water would be formed. But it is important to show that this formation does not ensue with tensions such as the above and in conditions where a very notable quantity of ozone is produced. The resistance of hydrogen to combination under these circumstances is so much the more remarkable as the conditions are precisely those in which oxygen combines with metals, with sulphurous and arsenious acids, iodine, and even with nitrogen. Vapor of water is not decomposed by the effluve in these conditions, and oxygen does not combine with water to form hydrogen peroxide. On the other hand, carbonic oxide and oxygen combine under the influence of similar electric tensions, though even in presence of an excess of oxygen a portion of carbonic oxide remains uncombined. Reciprocally it does not prevent the incipient decomposition of carbonic acid, and in a mixture of equal volumes of carbonic acid and oxygen after twelve hours five per cent. of the gas was decomposed into carbonic oxide and oxygen. This oxygen contained a very strong proportion of ozone or of percarbonic acid. The decomposition of pure carbonic acid by the effluve, effected in a space free from mercury and from oxidizable bodies, gives rise to special phenomena very worthy of interest, as they lead us to suspect the existence of percarbonic acid. The gas formed attacked mercury with extreme violence. It may be considered either as oxygen very rich in ozone or as containing a strong dose of percarbonic acid, C_2O_6.

ON THE EFFECT OF HEAT ON THE DI-IODIDE OF MERCURY, HgI_2.*

By G. F. RODWELL, Science Master, and H. M. ELDER, a Pupil in Marlborough College.

IN continuation of the experiments on the effects of heat on the chloride, bromide, and iodide of silver, which one of us has previously had the honor of communicating to the society, it was thought to be advisable to search in some of the other metallic iodides for molecular anomalies similar to those presented by the iodide of silver. Among these no substance appeared more likely to possess such anomalies than the di-iodide of mercury. This substance, as is well known, is dimorphous. In the amorphous condition it presents the appearance of a brilliant scarlet powder, which, if heated, fuses at 200° C., and volatilizes just above the fusing point to a vapor more than twice as dense as that of mercury. The vapor condenses to rhombic prismatic crystals, which frequently become scarlet while cooling, but which, if they still remain yellow when cold, instantly become scarlet if rubbed or otherwise mechanically agitated. According to Warington, this change is due to the transformation of the rhombic prisms into acute square-based octahedrons with truncated summits. If the yellow prismatic crystals are placed under the microscope, and are then touched, the change to the red variety may be observed to go on through the mass of contiguous crystals, accompanied by a slight movement, but the external form of the crystals remains unchanged, consequently pseudomorphous crystals are produced; and the larger rhombic prisms have been resolved into a mass of minute octahedrons. Frankinheim asserts that by the application of a very gentle heat both the red and the yellow crystals may be sublimed together, and he believes that the vapor of the yellow crystals passes off at a lower temperature than that of the red. Warington found that the precipitate produced by iodide of potassium in chloride of mercury appeared under the microscope to be composed of rhombic laminæ, which gradually altered their form by the truncation of the edges until they disappeared, while square-based octahedrons were produced in their place.

The iodide is clearly capable of existing in two crystalline forms belonging to different systems, and of passing from one form to the other, either by diminution of temperature or by simple mechanical means. Such a substance would seem to be likely to possess peculiarities in its modes of expansion under the influence of heat. In order to test this the iodide was submitted to the same experimental treatment as that employed in the case of the iodide of silver, and previously described in detail.

Homogeneous rods of the iodide of mercury were heated in paraffine in the expansion apparatus described and figured in the previous paper, and the extent of expansion due to a given range of temperature was noted. The apparatus was standardized by means of a rod of fine homogeneous silver. The same micrometer, reading to 1-5000th of an inch, was employed, and the mode of conducting the experiments was precisely the same as in the case of the iodide of silver. Two slight changes were made in the apparatus, however: the one consisted in the substitution of a massive stone base for the wooden one hitherto used; and the other the replacement of the glass rods moving in stuffing boxes by curved equal-armed levers moving over the rim of the trough, by which means the leakage of hot paraffine at the stuffing boxes was prevented.

Bars of the iodide of mercury were cast in clean glass tubes, and here at the outset the experimental difficulties

* Paper read at the Royal Society.

commenced. For not only was it difficult to obtain a homogeneous rod, on account of the volatilization of the iodide at a temperature slightly exceeding its melting point, but the rod when cold was found to be so brittle that it usually broke in the attempt to remove the glass envelope from the outside. Eventually good rods were procured by slowly melting the iodide in thin glass tubes and annealing in hot paraffine. When the whole was cold the glass was cut on the outside, and carefully broken off the ends of the rod, which were sawed plane by a fine steel saw, and then furnished with metal caps, and the rod was placed between the levers of the expansion apparatus. After heating the bar once or twice in paraffine to a temperature approaching its melting point longitudinal rifts appeared in the glass envelope, which was then easily removed, leaving a clean homogeneous rod of the iodide.

On heating a mass of the crimson amorphous iodide, it turns yellow at 126° C., and just before the melting-point is attained the yellow changes to a deep red-brown. The liquid resulting from the fusion has the appearance of liquid iodide of silver, that is to say, it has the exact color of bromine. The liquid when cooled solidifies to a red-brown solid, which speedily becomes yellow, and at 126° C., it changes to the crimson octahedral variety. Distinct cracking sounds, due to inter-molecular movements, were heard during the continuance of the change. Heat is absorbed when the red iodide changes to yellow, and is given out when the yellow inside changes to the red.

A bar of the iodide was placed in the expansion apparatus, melted paraffine was forced upon it, and when the index had become quite steady, a gentle heat was applied to the paraffine. The index showed a regular and slow expansion until a temperature of 126° C. was reached, when the bar began to change from the octahedral to the prismatic condition, and without further rise of temperature rapid expansion took place. The temperature was kept constant until the change was complete, and was then slowly raised. A regular expansion now took place under a higher coefficient than before the molecular change, and this continued until the melting-point was attained. The results were concordant.

The expansion in passing from the solid to the liquid condition was determined by weighing mercury in a tube, and afterward filling it to the same height with fused iodide. The specific gravity of each substance being known, and the weight of equal volumes, the expansion could obviously be readily determined.

The coefficient of cubical expansion for 1° C. from 0° C. to the point of change—126° C.—was found to be

0·0000344706.

At 126° C., during the change from the red octahedral to the yellow prismatic condition, the body increased in bulk to the extent of

0·00720407.

The coefficient of cubical expansion for 1° C. from 126° C., after the change, h, to the melting-point 200° C., was

0·0001002953.

Thus, if we suppose a molten mass of the iodide of mercury to be cooling down from 200° C. to 0° C., the following would be the volumes under the conditions indicated:

Vol. at 200° C.	of the liquid mass	= 1·1191147
" "	" solid mass	= 1·0190453
" 126° C.	(yellow prismatic condition)	= 1·0115378
" "	(red octahedral condition)	= 1·0043337
" 0° C.	.. ..	= 1·0000000

According to Schiff the specific gravity of the octahedral iodide is 5·91; while Karsten makes it 6·2009, and Boullay 6·320.

Two distinct specimens with which we worked gave respectively

(1). 6·3004
(2). 6·2941

The specific gravity of the fused iodide was found by the method before described to be

5·2865

Thus the specific gravities corresponding to the five marked conditions shown in the curve table are as follows:

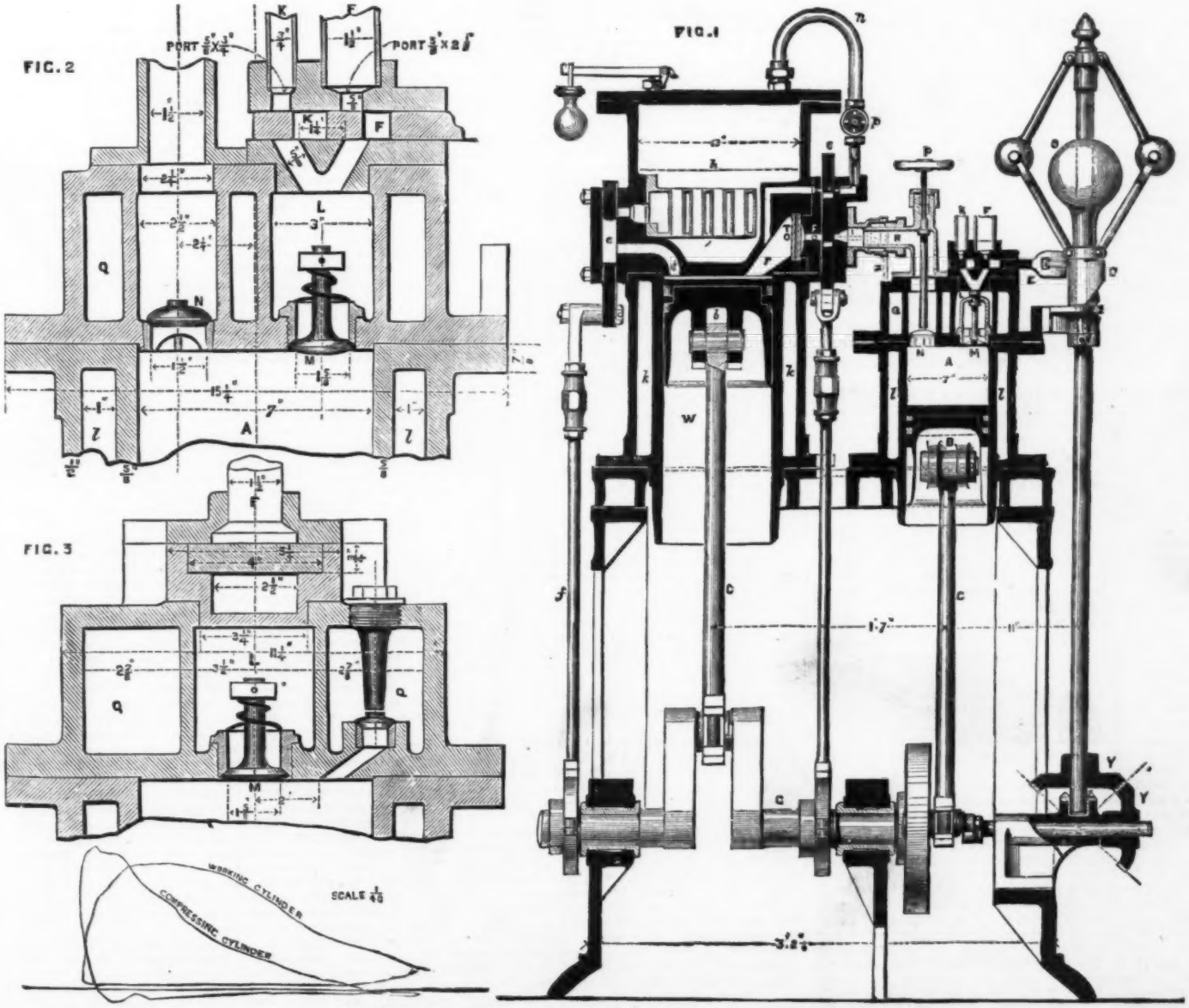
Sp. gr. at 0° C.	.. ..	= 6·297
" 126° C	(octahedral condition) ..	= 6·276
" "	(prismatic condition) ..	= 6·225
" 200° C.	solid	= 6·179
" "	liquid	= 5·286

COMBINED GAS, STEAM, AND AIR ENGINE.

AMONG the several improvements which have recently been made in motive power engines in which gas is the heating agent employed, that which we now illustrate is one of the most noticeable. It belongs to the type of aero-gas engines, wherein the gas is not used explosively, but for the rapid expansion of atmospheric air previously compressed in a cylinder forming part of the engine. An important feature of the engine also consists in the use of a small steam generator heated by the combustion of the gas and the hot exhaust gases from the power cylinder, the steam being used in the latter for increasing the power of the engine. The engine has two cylinders, one in which air is compressed in mixture with a determinate quantity of gas, and the other into which the mixture passes and is ignited by a constantly maintained flame, the air re-expanding from the pressure due to its compression, and under the influence of the heat of combustion of the gas and partial combustion of the air.

Referring to the illustrations, Fig. 1 is a sectional elevation of the engine, and Figs. 2, 3, 4, and 5 are details to enlarged scale. Fig. 6 is a perspective view.

In Fig. 1, A is the pumping or compression cylinder; B the piston working therein; C the connecting rod, connecting it direct with the crank shaft, G, on which is the fly-wheel, H, and bevel wheels, Y, which by means of the shaft, X, work the governors, O, connected with which is a sliding cam, D, sliding on a feather in the shaft, X, and connected with the governors, so as to be drawn upwards when, owing to the increased speed of the engine, the balls fly apart. The effect of this is to allow the runner at the end of the slide valve, E, to fall on the narrower part of the cam, D, and thus to open the air passage, F, and the gas passage, K, for a shorter time, admitting less gas and air until the pressure falls, and the speed of the engine is reduced, when the runner of the slide valve, E, again rides on the wider part of the cam, D. A spring, not shown in the drawing, gives the return motion to the slide valve, E, and maintains the runner in contact with the cam, D. After passing through F and K respectively, the air and gas pass into the chamber, L, whence they are drawn through the valve, M, into the cylinder, A, by the down stroke of the piston, B. By the return stroke of the piston, B, the gas and air are compressed and discharged partly through the pipe, R, into the combustion cylinder, and partly into a receiver, Q, from which the internal constant flame at T is supplied; N is a back-pressure valve; P is a stop valve. When this is screwed down the compressed mixture cannot pass into the pipe, R, and the motion of the engine is arrested; R being a tube through which the compressed contents of the air pump, A, pass to the slide valve, S, worked by the rod, g, and which admits the mixture through perforated brass disks and wire gauze at T into the interior of the working or combustion cylinder, W. A small pipe, Z, also proceeds from the receiver, Q, to the interior of the cylinder, W, opening at the point indicated by the black spot under T; b is the piston in the cylinder, W, and c the rod connecting it with the crank shaft, G; d is the outlet for the exhausted gases to the slide valve, e, actuated by the connecting rod, f, which admits them to an arrangement of tubes in the water chamber, h, from which they are afterwards led away through the exhaust port indicated into the center of the tube space. The water in h is in communication with the water in the jacket or casing, k, surrounding the cylinder, W. This water is also in communication with a similar casing or jacket, l, surrounding the cylinder, A. The heat of the combustion in the cylinder and the heat of the exhausted gases generate steam in the chamber, h, which passes by the pipe, n, opened or closed by the stop valve, p, and a port, V, in the slide valve, S, into the passage, r, and thus into the cylinder, W. The water employed is first admitted into the jacket of the compression cylinder, where it keeps that cylinder sufficiently cool, and is at the same time slightly heated. From this jacket it passes to that of the working cylinder, and gains in temperature while it cools the cylinder, and thence passes to the steam generator, h.



COMBINED GAS, STEAM, AND AIR ENGINE.

To start the engine it is first turned a few revolutions so as to compress air and gas in the cylinder, A, some of which passes into the space, Q. A small cock in the pipe, Z, is then opened and a plug opposite the spot under T is withdrawn and the gas ignited. The plug is then replaced and the pipe, Z, sustains a constant flame in the interior of the cylinder, W, at T, through which flame the mixture of gas and air compressed in A passes, and in thus passing is ignited. The consequent expansion causes the piston, *b*, to make a down stroke, imparting motion to the crank shaft, G, and at the same time the piston, B, of the cylinder, A, compresses and discharges into the pipe, R, and the receiver, Q, a fresh supply of gas and air. The momentum acquired by the fly-wheel brings the piston, *b*, of the cylinder, W, back to its highest position, and the above described action is repeated.

The only obstacle to the construction of engines of more than about 8 horse power is the necessity for working the

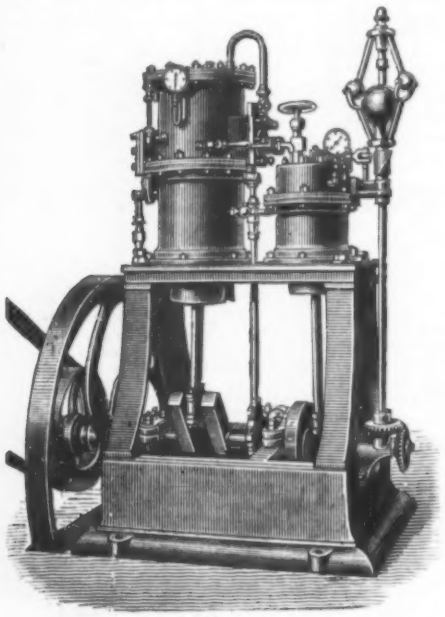


FIG. 6.

engine by hand for compressing some air and gas preliminary to starting. This, however, the makers, Messrs. Louis Simon & Son, Nottingham, have removed by providing an attachment by which one man is enabled to start the engine.

We recently saw one of these engines at work in the workshops of the makers, when diagrams from the two cylinders were taken, and the brake power of the engine ascertained with a simple form of brake. In this engine the working cylinder is 8 in. diameter, and the stroke 16 in. The compressing cylinder is 7 in. in diameter, with a stroke of 10 in. When running on the brake, the number of revolutions made was 136. The pressures in the working and compressing cylinders, as shown by the diagrams taken at the time, were respectively 22·1 lb. and 15·9 lb. per square inch. The latter takes into consideration the resistance against which the air was drawn into the cylinder, as shown at the bottom of the diagram, part of which was due to there being at the time rather too great a tension on the spring shown at M, Figs. 2 and 3. The power indicated by the working cylinder was then

$$\frac{8 \times 8 \times 0{\cdot}7854 \times 22{\cdot}1 \times 136 \times 1{\cdot}33}{33{,}000} = 6{\cdot}03 \text{ horse power,}$$

while that indicated as required for compressing the air and gas was $\frac{7 \times 7 \times 0{\cdot}7854 \times 15{\cdot}9 \times 136}{33{,}000} = 1{\cdot}87$ horse power.

Deducting this latter from 6·03 we have 4·16 as the net indicated horse-power of the engine. On the brake, however, the engine gave off nearly 0·08 of a horse-power more than this, which is not easily accounted for except on the ground that the diagrams from the compression cylinder are misleading, on account of the irregular form of the lower part of the diagram, showing the inspiration of the gas and air. The brake used consisted simply of two wood blocks, cut to fit and partly encircle a pulley of about 2 ft. 3 in. on the crank shaft. To the upper block an arm was attached, and at a horizontal distance of 2 ft. 9½ in. a weight of 59 lb. was suspended and maintained at a few inches above ground by the engine while running at 136 revolutions per minute. The diameter of the imaginary brake wheel was thus 5·58 ft., and the power given off =

$$\frac{5{\cdot}58\ \pi \times 136 \times 59}{33{,}000} = 4{\cdot}23,$$

or 0·08 horse power more than indicated. The brake may have been at fault as well as the compression cylinder diagram, and the fact that the gas supply was inefficient may have affected the result in a small degree. The pressure obtained, however, in the working cylinder was not as great as is commonly obtained. The diagrams given are two of many taken from each cylinder, and are fairly representative of all.

From the diagrams taken previously to those given above it was found that the indicated power was less than the brake power by one-fourth horse power. It was ascertained that this was caused by the partial choking of the wire gauge with sand or core material not previously completely removed in cleaning the cover casting, shown in Figs. 2 and 3. This choking caused an apparent increase in the pressure in the compression cylinder and a decrease in the working cylinder, and hence the anomalous result of the excess of brake over indicated power. The throttling of the air and gas in its passage to the working cylinder, while sufficient to materially alter the diagram, did not reduce the brake power in the same ratio. After this gauge was cleaned the results above given were obtained, the engine working smoothly, and giving no trouble from heating of the exhaust valve or other parts. It should be noted that the use of steam with gas and air effectually lubricates the working cylinder, the engine evidently works with very little friction, and the water arrangements keep both cylinders cool.

In practice it is found that the mixture of gas and air which produces best results is about 1 of gas to 10 of air, and this gives for the consumption of gas one-eleventh the capacity of the cylinder, or

$$\frac{7 \times 7 \times \frac{\pi}{4} \times 136 \times 10}{1728 \times 11} = 2{\cdot}75 \text{ cubic feet}$$

per minute, or, say, 165 cubic feet per hour, equal to about 39

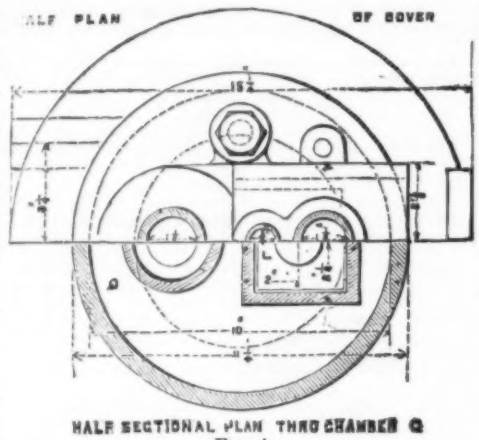


FIG. 4.

cubic feet per brake horse-power, as the maximum quantity that can be used. Inasmuch, however, as the cylinder is never quite filled, the consumption is considerably less than this, and in practice in ordinary working the governor cuts off the supply at a somewhat early part of the stroke. The result is that the consumption as registered by the gas meter is very often as low as from 26 to 22 cubic feet per horse-power per hour. The cost of this depends upon the position of the town in which the engine is employed. In South London, for example, this would cost about one penny per horse-power per hour.—*The Engineer.*

DESIGN FOR TOWN HALL.

WE publish opposite the elevation and plans of the recent design, by Mr. R. W. Gibson, from the London *Building News*, thinking it may have some interest for American architects. The author has endeavored to obtain a monumental character, constructionally truthful and undisguised. Classic forms are freely but appropriately adapted in the details, while the use of such anomalies as attached or superimposed orders, or two-storied pilasters, is carefully avoided. The site was described as fronting a public square or garden; the building would therefore be viewed from considerable distances. The plans provide the accommodation on basement, ground, and first floors, as required. No mention being made of other stories, the author supposed the design was limited to these. The assembly room is placed in the center of the site, surrounded by a wide corridor connecting the various departments. These, although not altogether under different roofs, are so arranged that each is distinct and separable from the others.

THOUGHTS ON OUR CONCEPTIONS OF PHYSICAL LAW.

By Prof. FRANCIS E. NIPHER, St. Louis, Mo.

[An address before the Alumni of the State University of Iowa, June 19th, 1878; delivered at Kansas City, December 23d, 1878.]

IN the short time at my disposal I wish to point out some reasons for the more general cultivation of a certain cardinal virtue which is so rare that I fear it has no name. Perhaps the words, "intellectual modesty," would come as near as any others in expressing what I mean. The world is very full of people who are ready to make assertions upon subjects which are evidently too difficult for them—in many cases too difficult for any one—to handle with any degree of certainty; and it doubtless often happens that some who have meditated studiously for years upon some such subject, arriving at no satisfactory conclusion, are regarded as objects of profound commiseration by others, who rush upon conclusions like the unthinking horse in the battle. It is natural that people should thus differ, as that some should have darker skins, taller frames, or more irritable tempers than others. To what extent these, and other differences which we shall point out, are blameworthy, we cannot attempt to discuss, but shall study the mental habits of men in precisely the same spirit in which we would study the habits of other animals. But I wish to show some tangible reasons for thinking that there are very few subjects upon which we can dogmatize, and that in any case it is unnecessary. I wish to advocate the cultivation of intellectual modesty, not merely because it seems to me to be one of the brightest ornaments of the human mind, but because of its vital connection with another cardinal virtue—intellectual honesty.

Perhaps this end will be best attained by considering the difficulties which are met in the investigation of any subject, when the sole aim is to find out the truth of the matter, and I have thought it proper to point out some of the difficulties to which we are subject in arriving at our conceptions of physical law.

The study of physical science has endowed the human mind with an attribute which is usually ascribed to and is thought to be characteristic of the divine mind. I refer to the power of prophecy. The astronomer can predict the position of the planets for generations to come, basing his predictions on the assumption—an unproved assumption—that only those causes which he has considered will act in the future, or, in other words, that the present order of things will continue. His power of prediction does not, however, extend indefinitely into the future, for there are, doubtless, many minor disturbances or perturbations, too small to be detected by the instruments which he can command, without many centuries of observation, the effects of which will become plainly apparent after the lapse of ages—that is to say, his power of prophecy is limited by his ignorance of certain facts, and, possibly, by his inability to solve the equations involved in a complete discussion of the subject.

It is for precisely the same reason that we cannot foretell the future destiny of every person in the world. But to a mind possessing all knowledge, and of infinite power, the one problem would evidently be as simple as the other.

We can readily imagine a being, possessing sufficient knowledge and ability, to calculate the orbits of every person now living. Such a being must know all that is to be known in regard to our mental and physical organisms, and the circumstances under which we are and will be placed. Having thus the initial stage and being able to trace succeeding events as logical sequences of the present, such a being could predict exactly what each of us will decide to do, under the present and all succeeding circumstances—could predict how far we will be physically and mentally able to carry our resolutions into effect.

But how awful must be the mind which could perform such a task! The most gifted mathematicians have, after enormous labor for two centuries, given an approximate solution of the interaction of three gravitating bodies, but they tell us that the methods used would not apply to four bodies, each of which exerted appreciable effects upon the others. How utterly beyond human power it would be to discuss the motions of the millions of chemical atoms contained in a single ounce of matter. Herschel has said that each of these particles is for ever solving differential equations, which, if written out, might belt the earth.

But our imagined ideal mind must deal with the physics of our globe, and the interaction of its myriads of men. The whole phenomena of meteorology must be calculated, not only for every part of the earth, but for all time. The effect of these climatic influences upon each man, and upon the grain or other productions of his industry, must be determined. The repressing effects of political and social tyranny, and the conditions of their existence; the refreshing effects of food and sleep, and the circumstances which may sometimes prevent communities or individuals from obtaining enough of them; the moral influence of men upon each other—to come to smaller matters, the effect of the present address upon each member of the present audience—all must be taken into account in this stupendous calculation. And now, given the myriads of vibrating atoms, and whatever else may constitute a man, and the external forces which act upon him, the manner in which the atomic motions of his body will be modified, and the resulting effect upon his thoughts and decisions must be determined. The calculation must be comprehensive enough to include the thoughts and actions of all men through all time. Such a being would be able to determine, by aid of some high order of mathematical analysis, how many persons will exist upon this earth five hundred years hence; would be able to locate each man, as astronomers predict the position of planets, and must be able to predict what task will then employ his hands, what train of thought will then be passing through his mind. A great famine occurs in China: it is produced by a combination of unfortunate circumstances, and the exact limit of its ravages could have been predicted ages before.

A certain closed line drawn upon the earth would mark out the area where 25 per cent. of the inhabitants would starve to death. Outside of this area would lie a belt of country, where 20 per cent. would die, and in this manner the whole of the melancholy facts could be represented. The discussion of the distribution of people and food, the means of transportation, the physical strength and wealth of individuals affected, and other matters involved in the question, would enable an all-powerful mind to determine to what extent each individual would be affected, and which ones would be strained beyond physical endurance. The position of each atom of matter in our world must be deducible, and the exact manner in which each atom moves and vibrates. Some portion of matter may repose for ages, locked in some rocky ledge. Infinite intelligence can calculate when a chance stroke from a workman's hammer may beat it loose, at what time it will be borne aloft on the fickle and inconstant winds, and when and where it will again fall, how it becomes part of some animal or plant, but everywhere its existence is recognized, and its path is traced by infinite mental power.

When we consider that our earth is but a speck in this universe of universes, that untold millions of suns and worlds are scattered through space, and that all are grasped by a knowledge equally profound, we begin to get some faint idea of the magnitude of that mind which can solve the general equations of the universe, and we can begin to realize how comparatively insignificant, how necessarily imperfect, are our highest mental achievements.

Whether or not there be such a being as the one we have here imagined it would be foreign to our purpose to discuss; but it seems to me that very few who talk fluently on either side of the question have ever tried to weigh, in a calm and dispassionate manner, the awful import of the words they use.

In such a calculation as the one we have here supposed, mental philosophy would become an exact science. The intensity of mental action, the strength of different minds, and quantities of pleasure and pain, would be determined. The logic of the wise and the foolish, the learned and the ignorant, the virtuous and the vicious, would be followed out to the conclusions which these minds would severally reach, under the particular circumstances in which each is placed.

Let us assume that one of the secret springs of human action is this: that in any given case we decide to do that which we then think will give us, on the whole, most pleasure or least pain, often deciding, however, to give up a greater pleasure, to be enjoyed only in the future, for a lesser one which we can enjoy immediately, precisely as we sometimes allow a note to be discounted in order that we may realize upon it at once; or, to take another case: we have in mechanics a principle known as the "principle of least action." Applied to the solar system, it affirms that each of the planetary bodies so moves, that the sum of the energy lost by counter attraction is less than if they moved in any other way. If this law holds in the interaction of men in society, it would mean, that however erratic the orbits of individual men may be, however much trouble may come upon them, or however much they may bring upon themselves, taking men as they are, the sum of human trouble is less than if men did differently, being what they are. Assuming that man is wisely constructed, mentally and physically, this is merely saying, in other words, that the present order of things is a wise one.

We are hardly in a position to assert that either of these statements is really a law of social physics. They are referred to here merely to indicate the nature of the results, which could be reached by mathematical analysis if we were able to discuss the interaction of moral and mental centers of action as astronomers discuss, approximately, the interaction of worlds.

Not only are we unable to predict for an infinite future, on account of the summing up of disturbances which cannot be detected in a short time, with our means of investigation, but, as before suggested, events wholly unexpected to our partially instructed mind—apparent breaches of continuity—are liable to happen at any time. A tribe of savages, not acquainted with firearms, may acquire a loaded musket. In toying with it for a time they become familiar with its appearance, and, as they think, with its properties. But some day they succeed in discharging it, an event which they are powerless to bring about again by an exact repetition of the act which brought it about before. Who shall say there are not hair triggers in the universe, upon which we may some time stumble? *"We can imagine intelligent beings living on a world surrounded by an atmosphere of oxygen and hydrogen. So long as they were unacquainted with fire, they might live for ages in fancied security," studying the laws of the evolution of their world, and making wise predictions in regard to its future. But the production of a single spark of fire would ignite their atmosphere, and wrap them in utter destruction. "We know not at what moment immense, and to us, wholly unexpected energies may be called into action. For all that our knowledge can tell, the volume of human history may be finished during the next hour. A great explosion on the sun may scorch us into cinders in a second. The earth may be dashed to pieces and dissipated into gas, by collision with some immense meteorite. We may become involved in a nebulous atmosphere of combustible gas, which would ignite a moment later; in fact, as was so eloquently pointed out by Mr. Babbage, there is no catastrophe too great, or too sudden, to be consistent with the reign of law, and the continuity of action."

*See Jevons' Principles of Science, 1877, pp. 742-748.

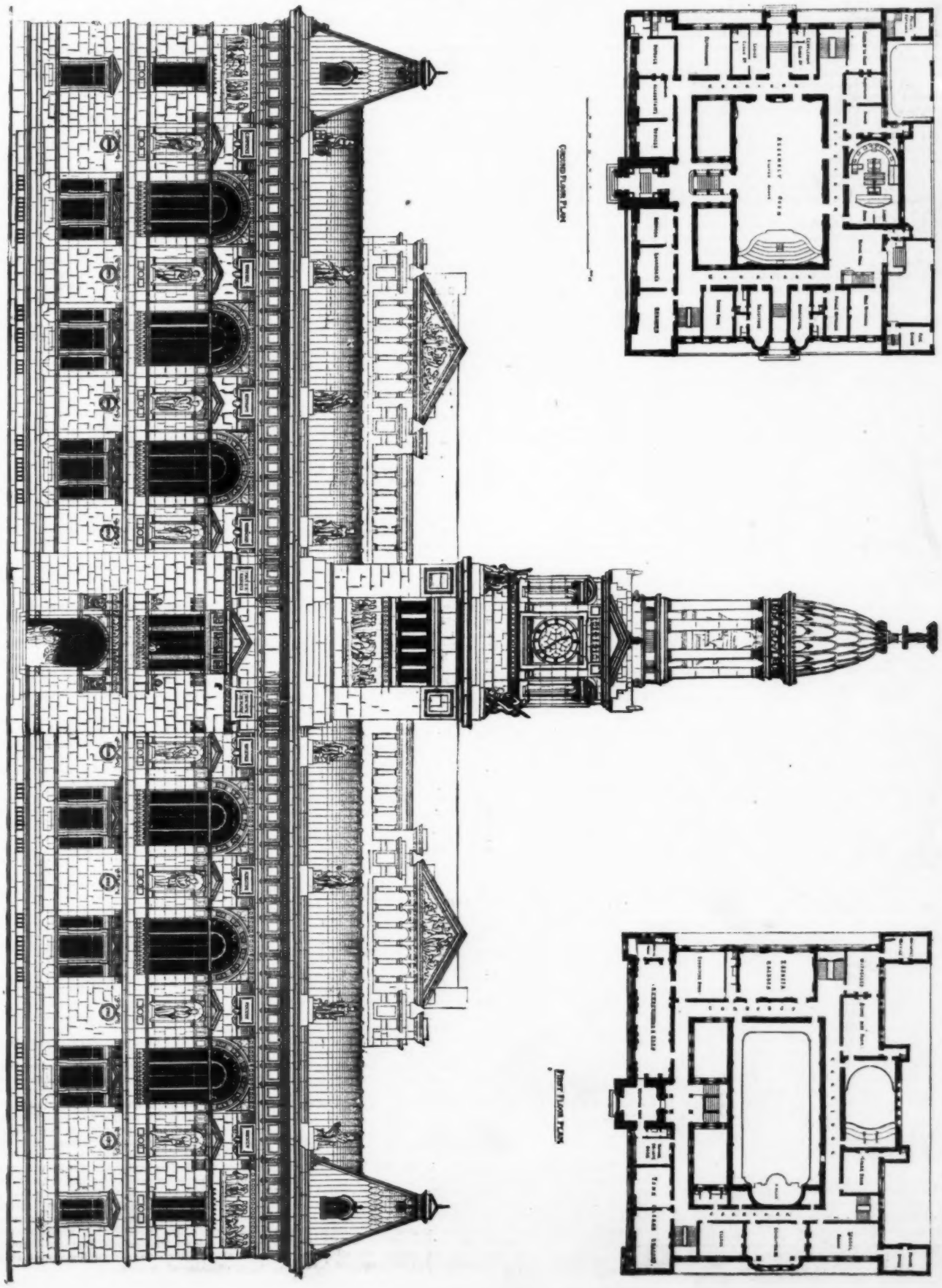
In the discussion of physical phenomena, we always ignore the greater part of the discussion, by neglecting those elements which are, or are supposed to be, unimportant. In so simple an operation as the weighing of a quantity of matter on a steelyard, we can discuss only the merest elements of the case. The student of physics would tell you, that the weights are inversely as the lever arms, but this is far from being the whole story. During the weighing, certain parts of the steel bar are heated; other parts are cooled; still other parts retain their temperature unchanged; electrical currents are set up within its mass; its magnetism is changed; its torsion and elasticity become different—in fact, to discuss all the changes occurring within the bar during so simple an operation, would infinitely transcend the power of the most gifted men.

If we could discuss completely the laws which govern phenomena, we should find them represented, in many cases, not by the comparatively simple formulæ, which have been found sufficient for practical purposes, but by infinite series, the first terms only of which our mathematicians have been able to deduce, and our physicists to experimentally detect.

What is here said of physical problems is also true of problems of pure mathematics. It is stated by mathematicians, "that those problems which have been solved are but an infinitely small part of those which can be proposed, that they are all special cases (although sometimes called general), and that if a problem were selected, at random, out of the whole number that might be proposed, the probability would be infinitely slight—that any human being could solve it."

Even those problems that have been satisfactorily solved involve ideas that we cannot comprehend. Let us take a simple problem in geometry. Imagine two wooden rods, or finite lines intersecting each other, and let us revolve one of them until they become parallel. Consider these lines infinitely prolonged, and let us see what becomes of these prolongations. As one line is revolved the point of intersection travels outwards. Finally the lines might seem to be parallel, but perhaps if we were to travel along the lines for a million of miles, we might come to the point of intersection. The mathematicians say, that when the lines have become parallel, the point of intersection will be removed to an infinite distance, which is, they say, equivalent to saying that the lines will not intersect. Where in space will these lines part company? Have they ends, which the point of intersection finally reaches, and which then separate from each other? No! The lines are supposed to be without end. However far the point of intersection may have traveled, we

DESIGN FOR A TOWN HALL—BY ROBERT W. GIBSON.



may straightway regard this distance, as represented by the first term of a divergent series of an infinite number of terms, each term of which is infinitely greater than the one which preceded it. We can form an independent conception of two infinite and absolutely parallel lines, but we cannot imagine how the infinite prolongations of intersecting lines can ever separate; nevertheless, we can continue the rotation of our finite line, until it passes through parallelism, and the point, or at least a point of intersection, comes traveling towards us from the opposite direction.

Prof. Jevons appears to think that our difficulty in such cases is due to an imperfect idea of infinite space.*

In the study of physics, our most certain experimental results force us to ideas equally beyond our power of realization. It is shown beyond question, that light moves over a distance of about seven times the circumference of our earth in a single second. We must look for something marvelous in any theory which can account for so marvelous a fact. According to Newton's theory, we should have particles of light, shooting off from a distant luminous body with this immense velocity, and, falling upon a mirror, their motion would not merely be checked, but the elasticity of these light particles must be assumed to be so perfect, that they rebound with an equal velocity.

According to the undulatory theory that light consists of vibrations of a medium which fills all space. Since the velocity of transmission of these vibrations is so great, it follows that the elasticity of this medium must be 10,000,000,000 times as great as that of the hardest steel. Space is not now regarded as a void, but as filled with a medium which, as Thomas Young remarked, "is not only highly elastic, but absolutely solid." And yet, as we walk through space, the solid atoms which compose our bodies experience not the slightest resistance. Such ideas, although they can be conceived, cannot be realized. We have had no previous experience with materials possessing such properties, and such ideas must necessarily appear strange to us; but they are no more strange than the phenomena of light which we directly observe, and which force us to this, or to some other theory, equally marvelous. Only those who have carefully examined the subject, can realize how weighty is the evidence in favor of the undulatory theory of light; but where such stupendous conceptions are involved, a slavish acceptance of any theory, even by them, would be in the highest degree objectionable. We are not the friends of theories, but of truth.

So in all departments of thought, we come sooner or later to depths which the human sounding line cannot pierce; we reach ideas about which it becomes hazardous to talk, unless one courts the position of a babbler of nonsense; we learn that all our "final" formulæ contain unknown quantities. As we are not infallible, we must, therefore, be cautious and modest.

It is not surprising, then, that in the progress of our sciences many errors of reasoning and in the interpretation of facts have been committed. You are all familiar with the ideas of Newton, in regard to the nature of light, ideas which were not in themselves absurd, which were firmly believed in by this man of transcendent power, but which were clearly negatived by results of subsequent experiment.

It was known long ago that rain-gauges placed above the surface of the ground caught less rain than those placed at the surface, and it is still taught in many of our text books that this is due to a condensation of moisture in the lower strata of the atmosphere. This idea is not absurd, but it has been shown† that this cause produces no appreciable effect, and that the observed effect is due to the action of the wind, "which sweeps some rain out of all gauges, and most out of those which are highest and therefore most exposed."

Lavoisier's idea that all acids were compounds of oxygen, received a complete refutation when the constitution of prussic and muriatic acids became known. In fact, the errors of scientific men are well nigh innumerable, not because they are men of science, but because they are men, and we are probably justified in saying quite in general, that if the man who never committed a mental blunder be found, we shall also find a man who never conceived a vigorous thought. The fact that the results of scientific men can usually be checked by observation and experiment, perhaps diminishes their liability to err, and enables them to discover multitudes of errors that would otherwise escape their attention. This does not tend to make the results of their investigations less weighty than results which have been reached by other processes, more purely mental. If men of science, with their severe methods of research, their habits of testing their conclusions by observation and experiment, are nevertheless led into wrong conclusions, what does it prove? Simply that the human mind, even under the most favorable circumstances, is fallible! Is there a class of men less liable to mistakes? It is precisely this experience which causes many to place a small value upon the unsupported assertions and speculations of any man, however honest, earnest, or able he may be.

On this point, one of the most admirable of experimenters, Faraday, has beautifully said: "The world little knows how many of the thoughts and theories which have passed through the mind of the scientific investigator have been crushed in silence and secrecy by his own severe criticism and adverse examination; that in the most successful instances not a tenth of the suggestions, the hopes, the wishes, the preliminary conclusions, have been realized."

In the 24th series of his "Experimental Researches," Faraday describes many tedious and intricate experiments, in which he tried to connect gravitation and electricity. "He labored with characteristic energy for days on the clock tower of the Houses of Parliament and in the shot-tower of Southwark, raising and lowering heavy weights connected with wire coils. Many times his great skill as an experimenter prevented him from being deceived by results which others would have regarded as conclusive proofs of his idea, and when the whole was done there remained absolutely no result." For although the results were wholly negative, Faraday could never accept them as conclusive against his idea, to which he had been led by his experiments on the relations between electricity and magnetism. His mental condition after this work was done is best described in his own words. "Occasionally, and frequently, the exercise of the judgment ought to end in absolute reservation. It may be very distasteful and great fatigue to suspend a conclusion; but as we are not infallible, so we ought to be cautious."

It is a matter of common observation that men who, like Faraday, have done much to widen the boundaries of our knowledge, are precisely the ones who are most frequently in a state of doubt, while those who have received all their knowledge at second hand are generally more ready with a positive decision and a reason for it, not necessarily because their intellectual integrity is less, but because they cannot realize how vain a thing the human reason is. To imagination and reason, controlled and checked by experiment and observation, are we to look as the source of the greatest advancement in science; but we are not to look for infallibility, and in cases where the reason alone is allowed to decide, where observation and experiment are impossible, the uncertainty must necessarily be greater. In many cases the fact that the subject is so intrinsically difficult that no experimental check is possible appears to inspire the investigator with a confidence in his conclusions that could hardly be re-enforced by absolute certainty.

But we have not yet exhausted the list of errors to which scientific men are liable in arriving at what we provisionally call correct conceptions of physical law. A few of them have carried their investigations into a domain in which certain hypothetical beings called "spirits" are said to be the main actors. It is exceedingly probable that a few trained investigators have been deceived in regard to the evidence of their own senses. This is not an unlooked-for result, as it can be readily reproduced in the performances of any expert juggler.

I have confined myself to the errors which scientific men have committed, and to which they are liable in their search for truth, not because they alone are liable to err, but because a discussion of the multitude of errors into which intellectual men of other professions have fallen, would be sure to give offense. But it is not the scientific mind which stands impeached—it is the human mind!

To what end have we then come? It appears that all scientific results are attended with some uncertainty. Sometimes the uncertainty is very small, and we are able to obtain a numerical estimate of it. In other cases it may be possible that a fundamental misconception of the truth may have been formed. As an instance illustrating what I mean, we may cite the case of the measurement of the Atlanta base-line by the engineers of the United States Coast Survey. The whole length of the base-line was nearly six miles, and three determinations of its length showed differences of about 3-10 of an inch—about a millionth of the entire length. It is safe to say that if these remeasurements had shown differences of ten feet there would have been no quarreling in regard to which measurement was right, but all would have been rejected, and if the engineers were not dismissed as incompetent they would, with feelings of mortification, have begun their work over again. It is curious to observe that in many cases where less skillful men attack problems infinitely more complex, reaching conclusions differing as widely as the poles, we have, instead of conscientious reinvestigation or a modest reservation of judgment, dogmatic discussions, empty words.

In the other case, where the error is likely to be a fundamental one, the probability of the truth or error of a conclusion cannot always be determined numerically, and will vary greatly in different minds. For instance, A may think he saw a ball drop into a box, and may feel certain that it is yet there; B is certain that it was a juggler's trick, and that the box is empty; C did not see the act, and has no opinion in the matter. About the fact there is no uncertainty: the ball is either in the box or not. No discussion can affect the matter in the least. The uncertainty is purely a mental affair, its degree depending upon the ability of the observers, their opportunities for investigation, and their previous training. Their differences on this subject will be wholly obliterated by an exposure of the interior of the box, and without the necessity for any discussion whatever. If the box cannot be opened, the matter will remain a legitimate subject for dispute. The fact that competent men think a subject worthy of dispute seems to me a good indication that the matter is, humanly speaking, uncertain. That unpleasant thing called intolerance, in those cases in which it is accompanied with sincerity, arises from an inability to see these points, and hence we have A making strenuous efforts to convert B and C to his own opinion, failing in which, he proceeds to burn them, to imprison them, to lampoon them in the newspapers, or to do some of the more quiet, but less effective things, characteristic of our own times, that the spirit of the age will permit. Perhaps no blame is to be attached to such acts. If they are failings they are simply to be counted in with the other failings to which well-meaning men are liable, and when the evil effects fall heavily upon us, it is perhaps wise to endure them with philosophic calmness, along with the other misfortunes which for some reason or other seem incident to human life.

In conclusion, allow me to say that it seems quite probable that human welfare does not require us to sit in judgment on the ideas of others. Thoughtful men are becoming more and more impressed with the vastness of the unknown, and the comparative insignificance of human achievement, while the demonstrated fallibility of human reason leads them to temperance and modesty of thought and expression; to appreciation, as well as toleration, of opposition and doubt. Certain it is that, if we preserve our intellectual integrity, we shall be unable to settle many of the problems that interest us most. If we decide upon some of them, and other persons still reserve their judgment or decide differently, we need not lose our tempers; they have not only decided differently from us, but we have also decided differently from them. It is important to notice that neither of these decisions has affected the truth in the least. If we feel called upon to defend the truth we are, after all, only defending what we believe to be truth, and possibly against men as honest and as able as ourselves. But why should we defend the truth? So long as the heart of humanity shall pulsate will not truth be cherished there? Why would it not be far better for each one to put himself in the attitude of a reverent searcher for truth? remembering always that the little decisions that we may reach are possibly wrong, that all of the honesty and ability in the world is not concentrated within ourselves and the comparatively few who think as we do, and that one can do nothing nobler than to make himself as intelligent and humane as possible, resolutely following out his highest convictions, and living at peace with himself and with all men.—*Kansas City Review.*

* Principles of Science, p. 707.

† Jevons, in Phil. Mag., Dec., 1861.

LIGHT AND LIFE.

THE question as to how life is affected by the different colors of the spectrum has at various times engaged attention, and plant life has apparently been more studied in this respect than animal. Two distinct series of researches lately described to the French Academy seem to afford some fresh insight into the matter, and it is interesting to compare them together.

One series, by M. Bert, was on plants; the other, by M. Yung, on the eggs of certain animals. M. Bert kept plants within a glass trough inclosure, containing an alcoholic solution of chlorophyl (very frequently renewed), and exposed them thus in a good diffuse light. The solution, which was very weak, and in a very thin layer, intercepted little more than the characteristic region of the red in the spectrum. This excluded part, then, was proved to be the indispensable part of white light, for the plants immediately ceased to grow, and before long died. It is in this red region (as M. Timirizeff has lately shown) that the greatest reduction of carbonic acid takes place. If red rays are kept from the leaf the plant can no longer increase its weight, it is reduced to consuming reserves previously accumulated, exhausts itself, and dies.

This part of the spectrum, however, though necessary, is not sufficient. Behind red glass plants may no doubt live long, but they get excessively elongated and slender, and their leaves become narrow and little colored. This is owing to the absence of the blue violet rays. Thus each region of the spectrum contains parts that play an active *role* in the life of plants.

Now turn to animals. M. Yung has experimented during three years on the effect of different spectral colors on the development of the eggs of frogs (the common frog and the edible frog), of trout, and of fresh water snails. It was found that violet light favored the development very remarkably; blue light comes next in this respect, and is followed by yellow light and white light (which two gave nearly similar effects). On the other hand, red and green appear to be positively injurious, for it was found impossible to get complete development of the eggs in these colors. Darkness does not prevent development, but, contrary to what some have affirmed, retards it. Tadpoles of the same size, and subjected to the same physical conditions previous to experiment, died more quickly of inanition when deprived of food in violet and blue rays than in the others.—*London Times.*

THE MINERAL SPRINGS OF COLORADO.

IDAHO SPRINGS is one of the oldest of Colorado watering places, and possesses, in an eminent degree, the characteristics and surroundings of a popular health and pleasure resort. Located thirty-four miles from Denver, by rail, in the valley of South Clear Creek, it is sheltered from the winds, and at an elevation of 7,800 feet above the sea, has a most delightful and health-giving climate; surrounded by high and well-known landmarks which, like the "Old Chief," "Squaw," and "Pappoose," lift their heads from 10,000 to 11,000 feet; possessing a number of medicinal springs, impregnated with iron, lime, soda, sulphur, and magnesia; provided with ample hotel accommodations; surrounded by picturesque drives and walks, Idaho Springs possesses many advantages over other Colorado resorts. Its proximity to Denver, Georgetown, Central, and other interesting mining and business communities; its large and well-conducted swimming baths; its eight soda springs—unite to render it one of the most attractive spots in Colorado and a favorite resort for invalids and tourists who come for rest and comfort.

In the language of a tourist whose travels have led him to all the prominent pleasure resorts and watering places of Europe, as well as of this country, Idaho Springs is, perhaps, for the tourist, the most celebrated resort in Colorado. Easy of access from Denver; 7,330 feet above the sea level; the location of some of the most efficacious mineral springs in the State; surrounded by scenery bold, grand, and novel, it attracts a large and increasing throng of visitors. No tourist should come within a day's journey of Idaho Springs without enjoying the satisfaction of a plunge in its famous swimming baths, the largest of which, the "Mammoth," is thirty by fifty feet in size and five feet in depth; the hot soda water, which pours in from the spring, being regulated to suit the bathers of the season. Connected with it is a large shower bath, comfortable dressing rooms, a barber shop, and all necessary appliances. The sensation produced by a plunge in this warm, soda water bath is peculiarly delightful, and, for rheumatic affections, wonderfully efficacious.

A short distance from the above is a smaller swimming bath, the "Ocean," twenty by forty feet and four feet in depth, generally used by ladies, who form into pleasant parties from the hotels and generally bathe in the evening. This is also fitted with a cold shower bath, comfortable dressing rooms, and is provided with polite female attendants. The medicinal properties of the bath are considered equal, and, by very many, superior to Baden, Ems, or Wiesbaden, of Germany. There are private bath rooms, where the natural temperature of the water at 110° can be enjoyed.

Near Soda Creek there is a cold soda spring which is strongly impregnated with sulphur, and is very effervescent and sparkling, and makes a delicious beverage. Dr. I. G. Pohle, of New York, made a chemical analysis of the water from the Hot Soda Springs, and found it to yield the following constituents, in the annexed proportions, to the gallon:

Carbonate of soda	30·80
Carbonate of lime	9·52
Carbonate of magnesia	2·88
Carbonate of iron	4·12
Sulphate of soda	29·39
Sulphate of magnesia	18·72
Sulphate of lime	3·44
Chloride of sodium	4·16
Chlorides of calcium and magnesium, of each, a trace.	
Silicate of soda	4·08
Grains	107·08

—*Colorado Tourist.*

ENGLISH ADVICE FOR COLD WEATHER.

THERE is no exaggeration in saying that the mortality from pulmonary affections would be considerably diminished were people to avoid that "catching cold" of which they so often and so lightly speak; and it is a matter of surprise to us that this fact, of which most of us are aware, does not lead to more precautions being taken by those who are anxious about either their own health or that of others. To take care that the body is thoroughly warm and well clothed just before going out in very wet or cold weather: to keep the circulation and warmth of the body rather by exercise of some kind than by sitting over great fires or in overheated rooms; to be sure that the temperature of the sleeping apartment is not ever so many degrees below that of the sitting room—these are three golden maxims, attention to which would prevent thousands from catching that chill or "cold," to the results of which so many valuable lives have been prematurely sacrificed.

EVOLUTION AND HUMAN ANATOMY.

By STANFORD E. CHAILLÉ, A.M., M.D., Prof. Physiology and Path. Anat., Med. Dept. Univ. La.

"In the place of miracle, natural science has substituted law."

THE "Descent of Man" closes with the once startling assertion, that "man still bears in his bodily frame the indelible stamp of his lowly origin." If this be true, then man's conception of an ever-loving and all-merciful God would be based on a benevolent reality, rather than on a malevolent fiction; since man would belong to a risen, not to a fallen race, and should exchange a discouraging belief in his degradation from a perfect parent for an encouraging faith in his own progressive development.

No one familiar with the history of the warfare between science and religion will be deterred from investigating the proofs of Darwin's assertion, though it is denounced by biblists as "evidently contrary to Scripture;" for such denunciations recall the history of many similar contests, of which three, at least, cannot, for the good of mankind, be too often repeated.

The rotundity of the earth was denounced for centuries "as contrary to Scripture,"[1] and the believers thereof were cursed and punished as "heretics, infidels, and atheists"—until Magelhaens, sailing ever in one direction, returned in 1519 to his point of departure.

The Copernican doctrine—that the planet of vain-glorious man was not the center of the universe, but that the sun was the center of our system, and that the earth moved around this center, not the sun around the earth—was declared, in 1616, by the Cardinals of the Roman Inquisition, to be "absurd, heretical, and contrary to Holy Scripture." The great book, which, in 1543, first taught this now familiar truth, was condemned to remain on the Roman "Index Librorum Prohibitorum" from 1616 to 1820. For advocating this truth Bruno was burned, Campanello tortured, Galileo terrified into perjury; and Luther and Melanchthon joined hands with the Pope, uniting Protestantism to Catholicism in upholding as scriptural[2] the woeful ancestral errors, to the overthrow of which Copernicus and Galileo owe their undying fame.

For centuries the creation of "the heaven and the earth" within six days[3] was an article of religious faith requisite to man's salvation. Even in 1850 the great Christian scientist, Agassiz, deemed it necessary, in his geological lectures at Harvard, to explain and apologize to an audience of college boys for teaching that the works of the Creator buried in the bowels of the earth testified irrefutably that it could not have been made within six days; and to defend himself against the maledictions hurled against him by that pulpit and press which, accepting at last the lesson once fiercely denounced, now uses his great but at one time execrated name to wage an equally hopeless battle against the doctrine of evolution—the only doctrine which explains to the biologist the Creator's mode of action in accord with such well-known facts as: that useful animals are burdened with useless organs, and harassed by other animals, useless and noxious; that organs and organisms are modified by, and are adapted to the varying conditions of existence; that use causes development, disuse the atrophy of organs, and thus new organisms may appear, while old ones may disappear; and that nature's work is done through laws simple, uniform, and constant.

It would be presumed that the marks of man's lowly origin, stamped indelibly upon his bodily frame, should be familiar to, at least, physicians, since they are forced to study human anatomy. But, in truth, few physicians, even though skillful anatomists, are well informed on this subject, for the reasons, that they pursue anatomy for practical purposes, not for philosophical deductions; that they study superficially, if at all, comparative anatomy, on which depends the significance, so far as evolution is concerned, of human anatomy; and that the indelible marks of man's lowly origin are to be found chiefly in three directions, of little importance to, and, therefore, little studied by the medical anatomist. These three directions are: the anatomy of the human being while within the womb—embryology; the anatomy of bodies deviating from the common rule—anomalies; and the anatomy of certain parts—rudimentary organs—imperfect in and useless to man, but perfect in and useful to lower animals. In these three neglected departments of anatomy will be found in abundance the indelible marks of man's lowly origin. Some of these will now be presented under the headings: Embryology, Anomalies, and Rudimentary Organs; however, every example presented will not be strictly confined to its appropriate heading, because the three subjects are so related that often an example of one is strengthened when united to an example of the other. This close relationship is so marked between embryology and anomalies, that the classification of monstrosities, which are simply gross and hideous anomalies, is based upon embryology.

EMBRYOLOGY.

If the different stages of man's development within the womb be not a synopsis or recapitulation of his genealogy during the enormous duration of terrestrial life—then these progressive stages are not only inexplicable, but also are so deceptive as to suggest the same explanation, once current as to fossils—that they were "delusions of the devil."

Man, "in action, how like an angel! in apprehension, how like a God! . . . the paragon of animals," originates, not, as our ancestors taught, from a homunculus or diminutive baby, but from a little ovule or cell, as does a fish, frog, snake, bird, and dog; it is about 1-125th inch in diameter, and apparently differs in no respect from the ovules of other mammals. In the hatching of this microscopic egg it successively presents in striking particulars the same forms of animal life disclosed in the successive strata of geology, and taught in our school books as the five progressive steps from the lowest to the highest vertebrates; for, the human embryo, at first invertebrate, subsequently assumes, in many things, the organization of a fish, an amphibian, a reptile, and a mammal, while becoming man-like—and yet has never ceased to be a human being. At the third week of hatching, this future man is a gelatinous, worm-like body, and even at the eighth week can scarcely be distinguished from the embryo of a dog. Among the details of this gradual development, the following deserve attention; but, to appreciate them, a comprehension of some facts in the development of lower animals is indispensable.

An egg, to grow, must, like every living thing, have air, water, and food for nutriment. How are these supplied? In all vertebrates, blood vessels, always the conveyors of nutriment, sprout from the microscopic embryo within the yolk or vitellus, and, extending over its surface, form a "vascular area," which conveys to the embryo all such nutriment as the water or air outside of this area may bring in contact with it, and also the nutritious yolk inside of this area; as the embryo thus consumes the yolk, this constantly diminishes, so that the vascular area gradually becomes a sac, which is called the "umbilical vesicle." The blood-vessels constituting first the vascular area, then becoming the vessels of the umbilical vesicle, form what is called the vitelline circulation, which, though the primary circulation of every vertebrate, is transient, disappearing by atrophy as soon as the yolk has been consumed, and other organs have been developed to supply the ever indispensable air, water, and food. This vitelline circulation supplies with nutriment the embryo of a fish, and of its brother frog, until converted into a minnow or a tadpole, when the sufficiently developed alimentary canal and gills or branchiæ provide the requisites for additional growth.

The egg of a bird and of a reptile is at first nourished by the same vitelline circulation which suffices to convert an embryonic into a perfect fish; but, long before the hen's egg becomes a chicken, this primary circulation begins, inexplicably to the special creationist, to disappear, while two new organs are developed—the amnion, with the more important allantois, which supply the embryonic bird and snake with a *secondary* circulation, in place of the disappearing *primary* one of the fish and frog. Thus, the hen's egg is provided with air and food until it becomes a chicken, when alimentary canal and lungs (not gills) discharge permanently outside the egg the functions discharged transiently within the egg, first by the vitelline, and second by the allantoidal circulation.

How grows the mammal's egg? As grows the egg of a woman. The human embryo is, by the "after-birth" or placenta—which is formed in large part by transformation of the allantois, first into the chorion, then into the placenta—grafted upon the mother's womb; and derives its nutriment from the blood of the mother. But, it must always remain an inscrutable mystery to the special creationist, that the Omnipotent delays thus to graft the embryo upon the mother until about the fourth month, and insists on forcing the human and every mammalian egg to secure its nourishment: first, through the fishy and amphibious vitelline circulation, which quickly disappearing, is replaced by the allantoidal circulation of the reptile and bird, which second circulation also quickly disappears, to be replaced by, third, the placental circulation. Now, let it be observed, that, on the one hand, the vitelline circulation of the fish is bathed in water, thence obtaining air in abundance, and that the allantoidal circulation of the snake is in contact with the delicate porous egg shell, through which air is readily absorbed; while, on the other hand, these two circulations in the human embryo are in contact, not with water nor with the external air, but only with one air-providing menstruum—the fluids secreted by the mother's womb—fluids which provide air, as also food, much less perfectly than is subsequently done by the blood of the placenta. Why, then, should the human embryo be furnished *temporarily* with the embryonic organs, first of a fish and amphibian, and then of a reptile and bird, prior to the development of the mammalian placenta—unless these organs, less perfect and more transient than the placenta, be indelible marks of man's hereditary descent? The student of vital phenomena cannot ignore the important purport of "the appendages of the embryo" and of the elementary facts now stated—facts which become of convincing significance when associated with those now to be presented.

The vitelline circulation is, by no means, the only indelible mark of man's piscine ancestry. Not until the sixth week does that *gill apparatus* disappear; which, permanent in fishes, is transient in the embryos of reptiles, birds, and mammals. The human embryo has on each side of the neck, as has an adult fish, "branchial arteries" (five), distributed to cartilaginous "branchial arches" (four), which have between them "branchial fissures" opening into the pharynx. From the "branchial arteries" of most fishes are developed, for aquatic respiration, numerous vascular "gill fringes," by which the air, dissolved in the water pouring through the "branchial fissures," is absorbed. But "gill fringes" are useless to animals which do not breathe in water, and since disuse of these fringes should cause their atrophy in a human embryo, just as it *does* in a tadpole, it is in perfect accord with nature's laws that these gill fringes are not present in the human embryo; even in some fishes they are dispensed with. In farther evidence that the embryonic branchial apparatus is perfectly homologous with the permanent gills of fishes it is found that, as the arterial system of the fish is formed from its branchial vessels, so the arterial system of the human embryo is formed from its branchial arteries, all of which gradually disappear by a conjoint process of atrophy, and of transformation into man's permanent arteries. Man's embryonic "branchial fissures," through which, in fishes, the air-supplying water passes off, also undergo transformation; however, as an anomaly, "original branchial fissures may persist in the neck, even in adults"[4]

Man's lungs are first developed as two little sacs, which, prior to the development of the trachea or windpipe, open temporarily, as the air sacs of fishes permanently do, into the upper part of the alimentary canal—usually into the pharynx.

Man's embryonic heart is at first a simple tubular pulsating sac, like that of the lowest vertebrate—that exceptional and wonderful, heartless, and brainless fish, the lancelot or amphioxus. This single sac is soon divided by a septum into two sacs, and thus man has temporarily the two-chambered permanent heart of fishes This piscine heart soon becomes a three-chambered reptilian heart, distributing, like it, impure venous mixed with pure arterial blood.[5] This snake-like heart does not become the perfect heart of the bird, mammal, and man, with its four completely separated cavities, until several days after birth; and, as an anomaly, the three-chambered heart may persist in man, causing the well-known "blue disease." As another peculiarity of the vascular system, man has but one great vein—the superior vena cava—to return the blood from the upper part of his body to the right auricle of the heart; but in his early embryonic condition, "*two* superior venæ cavæ open independently into the auricle. This condition remains permanent in birds, and in some of the lower mammalia, which possess both a right and a left vena cava superior, opening separately into the right auricle. Instances are occasionally met with, from arrest of development, of two such veins in the human body."[6]

The "Wolffian bodies" are the permanent kidneys of the fish, and of his immediate descendant the frog, but they constitute only the "false" or "primordial kidneys" of higher animals. The human embryo possesses them until about the third month, when they disappear by atrophy, giving place to the permanent true kidneys. These are in man smooth and unlobulated, but are lobulated in lower animals—so they are in the human embryo, and, as a frequent anomaly, this lobulation may persist in the adult man.

Fishes, amphibians, reptiles, and birds, are *cloacal*, that is, have one common fæcal and uro-genital outlet; so the human embryo is cloacal to the twelfth week of its existence. The urachus, a relic of the allantois and of this cloaca, running from the bladder to the navel, is in some animals a pervious duct. "It has been found (says Wilson's Anatomy) pervious in the human fœtus,[7] and the urine has been known to thus pass through the umbilicus."

The "descent of the testicle" from the abdomen of the fœtus is by a pouch continuous with the peritoneal sac of the abdomen. This continuity, permanent in many lower animals, as in the rabbit, is habitually temporary in man: but may, as an anomaly, persist, and thus cause the well-known "congenital inguinal hernia." Farther, this "descent of the testicle" is guided by a muscular cord, the gubernaculum testis, which at birth has lost its muscular character, and become (teaches Dalton's Physiology) "merely the anatomical vestige or analogue of a corresponding muscle in certain of the lower animals, where it has really an important function to perform" throughout adult existence.

The early embryonic womb appears bifid, and internally "presents a strongly marked triangular form, the vestige of its original division;" and, as anomalies, women may have not only "two-horned," but even "double wombs." Now, in apes the womb is slightly notched, and, therefore, more distinctly bifid than in women; in cetacea, solipeds, and ruminants, it is distinctly "two-horned;" and marsupials, as well as some rodents, have a "double womb."[8]

The placenta is formed in part by the mother, and in part by her offspring—in women these two parts are eventually soldered inseparably together; but in the earlier stages of development these parts are separable, as is always the case in the cow and other animals. The fœtal part of the placenta is formed by numerous vascular tufts of the chorion—called cotyledons, which in woman are soldered together into the smooth, single "discoid placenta;" but in ruminants the cotyledons continue separate, and they have habitually a "cotyledonous placenta:" as an anomaly, a woman may have a cotyledonous, instead of the usual discoid placenta.[9] The human fœtus is born linked to the placenta by the umbilical cord, which contains two umbilical arteries, and only one umbilical vein; but in the earlier stages of development there are two umbilical veins—which, always present in some lower animals, as (Topinard) in Cebian monkeys, may, as an anomaly, persist in the human fœtus.

Man's nervous system originates in a cord having one anterior bulbous enlargement, as is the permanent form of the cerebro-spinal axis of the amphioxus. This single bulb, first separating into the "three cerebral vesicles," subsequently develops man's complicated brain. Thus, as in the successive classes of vertebrates, so in the successive phases of the human embryo's life, are found developed all stages of the nervous system, from the simplicity of the amphioxus to the complexity of the highest mammal. Man's brain possesses no parts not present in the brains of the highest apes;[10] it differs from theirs, not in quality, but in quantity—in the greater complexity of the convolutions, in the lack of symmetry between the two sides, and in the greater size. But, our convolutions do not begin to be developed until the fifth month—even at the seventh month of fœtal life, man's brain is as unconvoluted and as symmetrical as is the adult baboon's; and, as anomalies, human beings may be born as destitute of brain as is the amphioxus—and the brains of congenital adult idiots, seldom weighing more than twenty-three, may not exceed even eight and one half ounces—while the average weight of the gorilla's brain is about seventeen ounces.

Man's bony system passes through a cartilaginous stage, which, temporary in him, is permanent in some fishes; and our bones present other indelible marks of our lowly origin, besides those which follow.

The single adult frontal bone (forehead) consists in lower animals of two separate pieces; such is its condition in the human embryo, and these two frontal bones are not united until the first year after birth—as an anomaly this union may never take place.

In some apes and other mammals the malar or cheek bone is permanently divided in two portions; and this sometimes occurs in the human embryo.

Lower animals have a distinct inter-maxillary bone for the incisor teeth of the upper jaw; so to the fourth month has the human embryo. The final union of the inter-maxillary with the superior maxillary bones is marked by a fissure for some three years after birth, and, by arrest of development, may never take place—thus causing, as an anomaly, the well-known deformity—hare-lip.

In the human embryo, "at one time, the two nasal passages or fossæ are closed at the bottom, a condition which is permanent in fishes; afterward they communicate, in front of the palate, with the mouth, as in certain amphibia; finally they open only into the pharynx, as in reptiles, birds, and mammals."[11]

In the human embryo the great toe is shorter than the others, and farther from them—even projecting at a right angle—as is its permanent condition in the quadrumana.

To the eighth week the coccygeal or tail bones of the embryo man project beyond the rudimentary legs, and as far beyond as in the embryo dog. This veritable tail, though usually aborted, may, as an anomaly, persist, as shown by Mr. Owen, who, April 25th, 1878, related to the Harveian Society, of London, "a case of a fœtus he saw, which had a tail that was *curled up on one buttock* and *distinctly moved*. It was successfully removed by ligature, and was now in the museum of Guy's Hospital. The child lived to sixteen years of age."[12] That the coccyx is an indelible mark of a true ancestral tail, is further indicated by the presence, even in the adult, of muscles which formerly moved it, but which, by long disuse, have atrophied and become rudimentary."[13]

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[1] See Is. xl. 22; Ps. lxxiv. 17; cxxxv. 7; Jer. li. 16; Rev. vii. 1.

[2] See Josh. x. 12, 13, 14; Mal. i. 11; Ps. civ. 19; cxiii. 3; Is. xxxviii. 8; Ec. i. 5; Hab. iii. 11.

[3] See Gen. i. 31; ii. 1, 2.

[4] Page 953. Vol. IV., Cyclop. Anat. and Phys.

[5] The reptilian heart has only one ventricular and two auricular cavities; while the human embryonic heart has only one auricular, but two ventricular cavities.

[6] Marshall's Physiology, Am. Ed., p. 977.

[7] The human being is termed embryo, until the beginning of the intra-uterine fourth month, and from this date to birth is called fœtus.

[8] Marshall's Physiology, Am. Ed., p. 974.

[9] Cazeaux: Midwifery, Am. Ed., p. 195.

[10] The highest apes, anthropoids, or anthropomorpha, are the gorilla, gibbon, chimpanzee, and orang.

[11] Marshall's Physiology, Am. Ed., p. 965.

[12] Br. Medl. Jour., May 11, 1878, p. 680.

[13] Gray's Human Anatomy. Am. Ed., p. 228, says, "the extensor coccygis is a slender muscular fasciculus, occasionally present. . . . . It is a rudiment of the extensor muscle of the caudal vertebræ present in some animals.

Finally, the poetical seven stages of man's life outside the womb are even surpassed by those within it, as numbered by embryologists. The most striking of these embryonic stages are, the Ascidian, the Amphioxian, the Piscine, the Reptilian, the Mammalian, the Quadrumanous, and the Human. What theory, other than evolution, offers even an attempt to rationally explain the significance of these stages, and of the facts now presented?

ANOMALIES.

Anomalies are deviations from the habitual construction of the body; the grossest are termed monstrosities, others constitute deformities, while the greatest number are simple deviations without being, in any wise, malformations. Most anomalies represent anatomical structures habitually found in lower forms of life, hence constitute what evolutionists term—*reversions*. Examples of monstrous, then of ordinary anomalies, will now be given.

A monster[14] is not, as until recent times was taught, an instance of "divine vengeance," nor a "work of the devil," nor a result of bestial intercourse, nor a lusus naturæ, nor the product of a creative force of special kind; but is due sometimes to excessive, sometimes to perverted, or, far more frequently, to defective embryonic development. Since the transient forms of the human embryo are, for the most part, repetitions of the persistent forms of lower animals, it is not singular that malformations due to arrested development should present a brute appearance; nor is it singular that our ancestors, ignorant of embryology, should long have erroneously ascribed beast-like monsters to bestial intercourse, and that this error should still find credence among the ignorant.

The human embryo is, in its earliest stages, as destitute of head, brain, heart, and extremities, as are the permanent forms of many lower animals; hence, from arrest of development, a human monster may be born as headless as a worm, as brainless and heartless as the amphioxus, and as limbless as a snake. Every variety and degree of deficiency in these and other parts, from complete absence to perfect development, may occur. Not only may development be arrested prior to the separation of the head from the trunk, thus producing a headless monster, but there may be a partial arrest producing a brutish, frog like deficiency of neck; not only may the four extremities be all wanting, as in the worm and snake, but the hands or feet may, turtle like, be attached to the shoulders or pelvis, and the two lower extremities may coalesce into one, as in fishes. Man's embryonic eyes are at first located on as diametrically opposite sides of the head as are the eyes of fishes, or of rodents; hence, by defect of development, may result human monsters, thus hideously deformed.

Before citing other examples of anomalies it is well to recall, that in addition to the above monstrosities, some fourteen instances of ordinary anomalies have already been presented in connection with embryology. To this list of reversions may be added the following indelible marks of man's lowly origin:

The vast majority of flowering plants, and also many inferior animals (as tape worms, slugs, snails, etc.), are "double sexed," and it is now generally conceded that *true* hermaphrodism is, in man, "not only possible, but probable."

Many lower animals have a "penial bone," and as a relic of this "a prismatic cartilaginous body has been occasionally found in the center of the glans" penis of man.[15]

Instead of having one nipple to each breast, or mamma, a woman may have, like some lower mammals, additional supplementary nipples; and her mammæ may, like the Monotreme's, be destitute of nipples. A woman may have, instead of the usual two pectoral mammæ, supplementary mammæ sufficient to furnish her with five breasts; she may have on the belly, the abdominal mammæ of Marsupials, or in the groin, the inguinal mammæ of Ruminants. She may have, like the Lemur, the lowest animal of man's order, the primates, two pectoral, and two inguinal mammæ. Among all mammals a marked relation exists between the number of mammæ and of young at one birth; and it is found that a woman may have occasionally, as some lower animals have habitually, two and even five living young at a birth.[16]

Man has occasionally a supplementary spleen, which is constant in the sturgeon, dolphin, narwahl, and doubtless in other animals.[17]

Many birds have a "vitelline cæcum," that is, a pouch-like process, or a "short, narrow, blind diverticulum, connected with the small intestine;" "a similar diverticulum is occasionally found in mammalia, and even in man."[18] Man may be web fingered and as web toed as a duck, and he may have two toes occasionally webbed, as they constantly are in the gibbon.

In man there is occasionally a simian conformation of the cartilage of the ear ("square above, rounded off, and without a lobule"); he may be born as destitute of external ears as a fish, frog, or snake, and as eyeless as a fish from the Mammoth Cave.

Like Esau, and many more recent instances, man may be as hairy as are most of his mammalian ancestors; and he may have, instead of ordinary nails, as solid claws on fingers and toes as have the carnivora.[19]

Anomalies of the bones are numerous. There may be complete fusion of the two parietal bones into one, as in rodents; and there may be, as in some lower animals, an interparietal bone. In the white race the two bones proper of the nose remain separate to an advanced age, as is not the case in other animals; but their fusion may occur early, especially in the inferior races of man, as, for instance, in Hottentots about the twentieth year; while in the chimpanzee and gorilla it occurs about the second year.[20] The spinous processes of man's 3d, 4th, 5th, and 6th cervical vertebræ are habitually bifid, but they are, especially in the inferior races, sometimes simple, as they constantly are in lower animals; however, the chimpanzee has two of these processes bifid, thus presenting in this particular a *transition* form. Man has occasionally—instead of his habitual twelve dorsal and five lumbar vertebræ—the thirteen dorsal and four lumbar vertebræ of the gorilla and chimpanzee, or the twelve dorsal and four lumbar vertebræ of the orang. Instead of twelve, man may have the thirteenth rib, out of which Eve was conjecturally made, and which some lower animals habitually possess.

Many animals have—to protect the principal artery and nerve of the humerus from compression—a "supra-condyloid foramen," which is occasionally found in man, it is said, once in every hundred cases; still more frequently is found a small hook-shaped process, as a rudiment of this foramen.[21]

In some fishes and crocodiles, says Mivart, several successive series of new teeth appear to replace old ones; so, occasionally in man, there may occur a third, and perhaps even a greater number of series of new teeth.

Occasionally in the superior, frequently in the inferior races, man's lowly origin is stamped upon him by the projecting upper incisors of the anthropoid, by his prognathous under-jaw, and by his monkey-like "facial angle."

A man has more than five hundred separate muscles; variations in number and attachment are frequent, particularly in negroes; and these variations or anomalies constantly illustrate reversions to lower animals, and especially to the anthropoids. Topinard asserts that the sternal muscle of mammals is present in 18 of 600 men; that the ischiopubic muscle, constant in the majority of male animals, is present in 19 of 40 men; that the levator claviculæ of most apes is present in 1 of every 60 men; that in one man seven muscular peculiarities of certain apes have been found; and that a marked muscular peculiarity of anthropoids and monkeys, as distinguished from men, is the habitual presence in the former and absence in the latter of an accessory fasciculus of the latissimus dorsi, but that this fasciculus has been "observed in a rudimentary state in some negroes."[22]

Huxley teaches[23] that man has usually only two muscles[24] which the anthropoids do not have, but that the one is sometimes and the other is frequently wanting in man; that the anthropoids have usually only four muscles[25] which man does not have, but that all these are sometimes absent in anthropoids and present in man; and, in fine, that "all the apparently distinctive peculiarities of the myology of the anthropomorpha are to be met with occasionally, as varieties in man."

RUDIMENTARY ORGANS.

Rudimentary organs found in all kinds of plants and animals are the perfectly useless, and at times even detrimental relics of useful organs in lower forms of allied plants and animals. The presence of such relics in the adult, and their better development in the embryo, are among the most convincing evidences of evolution; while to him who believes that all things were specially created for some special and useful purpose, these relics must continue to always be "inscrutable mysteries." How is it possible to explain, except by the *derivative* creation of evolution, such facts as follow?

The canine and upper incisor teeth of ruminants exist in a rudimentary state, but are invisible, because they never rise above the gum; so, also, the fœtal whale has teeth which are never cut. Many insects have wings, lying under wing-cases which are firmly soldered together. Even entire limbs may be rudimentary—certain snakes having hind legs hidden beneath the integument.[26] There often reappear the stump of a tail in tailless breeds, minute dangling horns in hornless breeds of cattle, the vestige of an ear in earless breeds, and the rudiments of eyes in eyeless animals.

The rudimentary organs of man, if neither so surprising nor so numerous as in lower animals, are as significant. To the several examples heretofore presented will be added the following:

The porpoise, the hedgehog, horse, and other brutes have a highly developed group of skin-muscles, termed the panniculus carnosus—which is rudimentary in man, being represented only in part; for instance, by the platysma myoides in the neck, by the occipito-frontalis over the skull, and by occasional traces in the arm-pits and other localities. The fibers of the rectus muscle of the abdomen are interrupted at intervals by from two to five transverse tendinous intersections, termed lineæ transversæ, which are the vestiges of ribs in some mammals, and especially in reptiles.[27] Although few men can move the external ear, and even these imperfectly, yet all men have three rudimentary ear muscles,[28] which are the analogues of large and important muscles in some of the mammalia. A small projection, sometimes found on the superior border of the helix of man's ear, is believed by Darwin to be the vestige of an ancestral *pointed* ear.

Man, and all male quadrupeds, have rudimentary mammæ, which, considered in connection with "double-sexed" anomalies, have, no doubt, a deep significance. Man has, over the whole body, rudimentary hairs, which are supposed to be vestiges of a uniformly hairy coat. Man has a small laryngeal sac, the ventricle of the larynx, which is believed to be the rudiment of a very large cavity in anthropoids and in other animals. The white man's third molars, or wisdom teeth, are sometimes never cut, are especially prone to decay, have only one root instead of two or three, and are smaller than the first and second molars; since this is not the case in lower animals, nor in apes, nor in the inferior races of man, it is believed that the European's wisdom teeth are *tending to become* rudimentary.

In mammals generally, and in lower vertebrates, there is present in each eye a "nictitating membrane," or "third eyelid," which often, if not always, springs from the inner and nasal side of the eyeball; in the same part of man's eye is constantly found, as a rudiment of this third eyelid, the semilunar fold, or "plica semilunaris."[29]

One of the best known and most remarkable rudimentary organs of man is that worm-like appendage to the cæcum, or head of the large intestine, called the appendix vermiformis cæci. The highest apes, and, it is said, the marsupial wombat, are the only animals which share with man the honor of possessing this curious and useless organ—which serves no purpose, thus far conceived by human ingenuity, except either to occasionally cause death, as by impaction of a cherry-stone, or to present a very indelible mark of man's lowly origin. To properly estimate this cæcal appendage, a few facts in comparative anatomy must be understood.

The cæcum is a pouch-like elongation of the large intestine at its junction with the small intestine. The ant-eater and armadillo have, as birds generally have, two such blind elongations, or a "double cæcum;" the manatee has a bifurcated cæcum; but mammals, as a rule,[30] have only one cæcum, which, always large, may be of enormous size, as in the hare, the indris, the marsupial koala, the horse, and in ruminants. The cæcum of the koala is three times the length of its body, while that of the horse is longer than three feet, and holds more than seven gallons. Further, lemurs have a peculiar cæcum, in that it is "drawn out into an elongated conical termination;" and some, if not all, carnivora, have a "spirally twisted" cæcum.[31]

These facts seem to throw light on the gradual transformation of the large mammalian cæcum into man's insignificant organ,[32] which has attached thereto a small, elongated, worm-like, conical, and spirally twisted appendix. Can any doubt remain that this appendix is the vestige of the long and large cæcum possessed by man's mammalian ancestors? If so, the doubter is required to explain why it is that in his own, as in every man's early embryonic development, *his* cæcal appendage was, at first, long, of large size, and as wide as the cæcum itself, so wide that the small intestine seemed to be inserted into the side of the large intestine, leaving a large pouch-like free end, which, becoming by degrees conical, was gradually constricted and twisted into the adult's familiar, small, and worm-like appendix? Such doubters have no refuge from the Scylla of "*derivative creation*," except in the Charybdis of "*inscrutable mystery*."

Comparative anatomy has already acquired sufficient knowledge to increase the long list, now given, of the indelible marks of man's lowly origin. As the future perfects this knowledge, not only will there be many important additions, but a brighter light will be thrown on the facts herein presented. However instructive such detailed facts may be, yet only a fraction of the evidence in favor of evolution depends on human anatomy; and the general facts are as decisive as are details to him thoroughly imbued with a conviction of the simplicity, uniformity, and constancy of nature's laws. For chemistry teaches that man's chemical, microscopy that his histological, morphology that his homological structure agrees with the whole animal kingdom. Palæontology has stamped in permanent letters of stone the same succession of animal life, impressed by fleeting hours on the offspring within the womb of every mother: and comparative anatomy, physiology, and pathology present innumerable general, as well as special facts, to prove that man, though ultimately formed of those chemical elements which constitute, in part, "the dust of the ground," was not formed directly out of these lowly dead inorganics, but had his immediate origin from the very highest organic living matter.—*Medical Record.*

PROTRUSION OF LOWER JAW, AND TREATMENT.

AT a recent meeting of the New York Odontological Society, Dr. George S. Allan, of New York, gave an account of a case of "protrusion of lower jaw, and treatment."

In April last a little girl was brought to me for dental treatment only, but noticing that the lower jaw presented a very marked protrusion, I advised that it should be immediately treated, with a view to the removal of what was a positive deformity, and was asked to undertake the treatment. The deformity was entirely in the under jaw, which was, as usual in such cases, of abnormal width, and projected so that the lower arch extended outside the upper throughout its whole circuit.

Usually, in such cases, I direct delay, before beginning to operate, until the permanent teeth are all in place. But, after consideration, I adopted for this case a different plan. As the irregularity appertained to the jaw itself, and not to the arrangement of the teeth, I decided to operate upon the jaw alone, and to bring about a correct articulation of the teeth as a sequence. My first plan was to construct two dental splints or plates of rubber, one each for the upper and lower jaws, having a protuberance on each in the nature of an inclined plane, which would act, during closure of the jaws, to force the lower one backward. But I did not persevere in this direction, for I soon found that it would be of little use. Then, directing the child to continue wear-

[14] Human monsters are reported by some to occur as often as once in every 1,000, and by others once in every 3,000 deliveries. Fortunately many die early.

[15] Huxley's Vertebrates, p. 417.

[16] Churchill reports that in 448,988 deliveries, twins occurred once in 78, and triplets once in every 5,831 cases.

To correct frequent misapprehensions of two sexual questions, it may be here added, that Flint's Physiology, p. 875, teaches that monkeys, as well as women, have a monthly catamenial discharge; and Topinard's Anthropology, p. 150, teaches that the gorilla and chimpanzee are monogamous.

[17] Mivart's Element. Anat., p. 484.

[18] Marshall's Physiology, Eng. Ed., p. 167, v. 2; and p. 622, Wilson's Anatomy.

[19] In 1864 one such case was seen by the writer, at Macon, Ga., in a Confederate conscript, who stated that his long, round, solid claws were inherited, and had been transmitted to one of his children.

[20] Topinard's Anthropology, p. 127.

[21] Gray's Anatomy, Am. Ed., p. 131, teaches, that this foramen, or its rudimentary hook-like process, are, when present, found "some two inches above the internal condyle."

[22] Topinard's Anthropology, p. 98. However, Gray's Anat., Am. Ed., p. 272, teaches that an accessory of the latissimus dorsi is found in one of every 13 men.

[23] Huxley's Vertebrates, pp. 406, 417.

[24] The extensor primi internodii policis, and the peroneus tertius.

[25] The levator claviculæ, dorso-epitrochlearis, scansonius, and abductor ossis metacarpi quinti digiti.

[26] Dalton's Physiology, p. 614, teaches that the anterior extremities of the embryo frog are at first concealed beneath the integument.

[27] Mivart's Element. Anat., p. 339, says, "The lineæ transversæ may be absent, as in the hedgehog, etc.; or they may be seven in number, as in the raccoon, or they may be replaced by regular abdominal ribs, which subdivide the rectus into a longitudinal series of successive segments, as in the chameleon."

[28] The attolens, attrahens, and retrahens auris.

[29] In dogs, cats, and carnivora generally, the eyelids do not separate from each other until eight or ten days after birth, and in the human fœtus they remain adherent to the seventh month.

[30] Human anatomists habitually assert or imply that all mammals have a cæcum; but Mivart's Element. Anat., pp. 447-8, teaches that "the presence of a cæcum is not quite constant in man's class," for "it may be wanting altogether, as in the hedgehog, weasel, porpoise, and others."

[31] The cat, dog, and other carnivora, says Chauvan's "Comp. Anat. of Domesticated Animals," p. 417.

[32] Man's cæcum is a small reservoir, only 2½ inches in length; his cæcal appendage is very variable in length, usually about three, it may be six, inches long. This variability is significant.

ing the upper plate, I set to work to make an apparatus that would pull the lower jaw back, keeping the upper splint alone in place.

As you will see from the photograph taken at the time she was wearing this apparatus, it consists of two parts. For the lower part I made a brass plate to fit the chin, having arms with hooked ends reaching to a point just below the point of the chin. These arms were arranged in such a way that the distance between them could be altered at will by simply pressing them apart or together. The upper part consisted of a simple network going over the head, and having two hooks on each side, one hook being above and the other below the ear. When this apparatus was completed, and in use, there were four ligatures of ordinary elastic rubber, pulling in such a way as to force the lower jaw almost directly backward. I relied upon the elastics attached to the lower arms to do the main work. The upper elastics were simply used to keep the mouth closed so that the lower elastics would not pull it open, the upper elastics being made just strong enough so that the child, in the natural operations of eating and talking, would not have to strain the muscles of the mouth to keep the jaw open. The work proceeded very rapidly, much more so than I had expected, so that at the end of two months, instead of six (as I had told the mother of the child it would take), the irregularity was almost entirely cured.

At about the end of the first month there came a stop, and for two weeks I could not get the jaw to move one particle, which puzzled me very much. The mother said the child wore the apparatus regularly, day and night, and she knew of no reason why the work should not go on. I had the child brought down to the office in the morning, and kept her there all day watching her, and I found that when she was busy at reading or play she would push the network on the head back so that the elastics did not pull. Thus that puzzle was solved. I then directed the mother to watch her carefully, and keep the band of the network well on the forehead, and also more carefully directed the young miss herself, and warned her that she would lose all that had been done if she was not more careful in the future. After this the work went on steadily to completion.

In a little over two months the under teeth were completely inside of the upper. The cast I hold in my hand represents the condition of the teeth when I commenced operations, and this one shows the condition of the teeth at the present time. In my absence during the summer the child wore the elastics only during the night, and on my return I found that the jaw had pushed out a very little, not enough to throw the upper teeth within the lower teeth as formerly, but so that the left upper incisor was just touching the tip of the lower one. I had the apparatus reapplied, and this slight relapse soon disappeared. I see no reason why, in all such cases, either this or similar methods of procedure should not be adopted. If taken at this age, or even when the child is older, I cannot see why success should not attend the efforts of the dentist.

I was puzzled at first to understand how I had obtained so great an amount of recession in the lower jaw, but on carefully examining the skull and position of the parts at the child's age, the proper solution of the problem soon presented itself. The jaw at that period of life is completely developed and hardened. When a child is one year old the union between the two lateral halves of the jaw takes place, and at eight years the jaw is solid. Consequently, any efforts that may be made will not affect the jaw bone itself. The only way in which the change can be made is by pushing back the condyles of the jaw into the glenoid cavity. Allow me just here to show you the skull of a child about five years of age. The articulation between the glenoid cavity and the condyle is peculiar, in that there is a double synovial membrane, between which there is a cartilaginous bursa.

This cartilage gives way, and absorption takes place at the posterior side of the condyles, with filling in of the anterior, so that the whole operation consists in pushing the condyles of the lower jaw into the glenoid cavity of the temporal bone. Until the articulation has again receded by the natural protrusion of the teeth, I suppose the child will have to wear the apparatus more or less. I had it taken off to bring here this evening. I should certainly, in any similar case presented hereafter, even at twelve or thirteen years of age, before attempting any other procedure, try this first and thoroughly.

Dr. S. G. Perry, New York.—Is the chin plate lined with cotton or other soft material?

Dr. Allan.—I had it made with a pad between the chin and the plate, but to my astonishment the child preferred to wear it without the pad. I had the plate nickel-plated. I would say that the main difficulty which I apprehended was that inflammation might occur in the articulation. I cautioned the child and the parent frequently not to push the matter in the least; insisted that the child should be watched carefully, and the moment there was any soreness of the parts, the elastics should be taken off or loosened in tension power very much. But to my astonishment the child, from the beginning to the end, was free from complaint of pain. The apparatus hurt her feelings and pride more than anything else. I never had a case that went on more rapidly and easily than this one.

Dr. C. A. Marvin, Brooklyn.—How long will the patient have to wear that appliance?

Dr. Allan.—Only until the teeth articulate perfectly, which, I suppose, will be in about a year.

Dr. Marvin.—You do not look for any change in the shape of the lower jaw?

Dr. Allan.—It is impossible. All the change is the moving of the articulation back in the glenoid cavity.

Dr. Francis.—Would you treat a case like that in a child fourteen or fifteen years of age?

Dr. Allan.—I do not know. I think I should try it. Looking at adult skulls, I find the glenoid cavity is so shallow and the condyle so large that there is room for the jaw to be moved back one-sixteenth of an inch or more. I would not advise the process in any case over twelve years of age; but it seems to me that up to that age I would advise it. Dr. Northrop says he had a similar case years ago, and he carried it through successfully.—*Dental Cosmos.*

HONORS TO THE LATE PROF. HENRY.

ON the afternoon of January 16th, in the National House of Representatives, memorial services in honor of the late Professor Joseph Henry were held in the presence of a vast audience. The President and his Cabinet, Chief Justice and Associate Justices of the Supreme Court, the United States Senate, the alumni of Princeton College, and members of the various societies with which Professor Henry had been associated, occupied seats on the floor, as did also a number of ladies. After the opening prayer by Dr. MCosh, of Princeton, addresses were delivered by Vice-President Wheeler, after reading the address of Senator Hamlin, who was unable to be present, President Withers, Professors Gray, of Harvard, and Rogers, of Boston, Representatives Garfield and Cox, of New York, and General Sherman. Prayer was then offered by Rev. Byron Sunderland, and the invited guests having retired, the House adjourned.

WILLIAM HARVEY.

IN a recent number of the SCIENTIFIC AMERICAN SUPPLEMENT (No. 160, p. 2537) we gave an interesting account, from the pen of Dr. Richardson, of the present state of the scene drawn from an incident in his life—along with a brief biographical sketch.

Born at Folkestone, Kent, April 1, 1578, William Harvey, at the age of 15, was sent to the University of Cambridge. From thence, after his graduation, he repaired to the University of Padua, where he attended the lectures of Fabricius d'Aquapendente (Fabrizzio) and other eminent professors of medical science. Here, in 1602, he graduated as doctor of medicine. On his subsequent return to England he settled in London, and was appointed, in 1609, physician to St. Bartholomew's Hospital. In 1615 he became lecturer on anatomy and surgery in the college of physicians. It was about the year 1619, while he held the latter position, that he

FIG. 1.—WILLIAM HARVEY.

sarcophagus that contains all that is mortal of William Harvey, and also a view of Hempstead Church, wherein the remains of the great anatomist have lain undisturbed for two hundred and twenty-one years. We present herewith two illustrations—one a portrait of Harvey and the other a is supposed to have made the discovery of the circulation of the blood, his profound studies in this direction having been a continuation of those of his master, Fabricius, who had already discovered the valves of the veins. Shortly afterward he was invited to deliver a lecture before the professors

FIG. 2.—HARVEY SHOWING TO CHARLES I. AND TO THE PHYSICIANS OF THE ROYAL COLLEGE OF LONDON THE PHENOMENON OF THE CIRCULATION OF BLOOD IN A LIVING HIND.

of the Royal College of London, giving his ideas on the subject of this important phenomenon. Charles I., too, was much interested, and, desiring to hear from the discoverer's own lips an exposition of his theory, Harvey responded to the king's wishes by demonstrating it several times before his Majesty, several persons of the court, and the physicians of the University. There happened to be at the court of Charles I. a young nobleman, the Viscount Montgomery, who, through an accident, had suffered the loss of some of his left ribs, so that his heart could be seen and its movements felt by placing the hand on his chest. Harvey greatly profited by the presence of this person to study the movements of the heart and the circulation. This fact is probably the origin of the story that Charles I. authorized his physician to make a demonstration of his theory on the body of a living criminal. The physicians of the Royal College of London received the doctrine of circulation with great favor, and pressed its author to at once publish his discovery to the scientific world in a printed volume: but Harvey, with a commendable caution that might well be imitated by physicians of modern times, refused all such entreaties, and waited nine years before publishing the result of his labors. In the meantime he kept repeating his experiments, studying the problem in all its aspects, and proposing to himself and answering all sorts of objections. His work, which is a masterpiece as regards perspicuity of style, was published at Frankfort, 1628, under the title of "Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus." In this book Harvey makes known the numerous experiments that he had performed on animals of all classes, and establishes the fact that in the contraction of the heart there are three things to be distinguished: (1) the heart contracts so as to diminish its transverse and increase its vertical diameter; (2) during its contraction the fibers of the heart become compressed, so that the organ feels like a hard body when the hand is placed against the chest; (3) the heart rises and its extremity strikes against the walls of the chest, and it is to this movement that is due the beating that is felt externally. He afterward shows that the phenomenon of the *pulse* is due to the dilatation of the arteries caused by the blood being forced forward by the contraction of the left ventricle. He also proves that in the contraction of the heart it is the auricles which first contract and send into the corresponding ventricles the blood which fills them, and that the ventricles in turn propel the blood from the heart through the arteries to every part of the body. He asserts that the functions of the valves of the veins are not, as his master, Fabricius, had taught, to prevent the entrance of too large a quantity of blood and so distend the vessels, but to prevent the return of the blood to those parts from whence it was expelled. Finally the facts announced by Harvey were so clear, and established by so numerous proofs, that it seems that such a brilliant conquest of the human mind should have at once found support among all his contemporaries. But such was not the case; the discovery was so unexpected, and so manifestly contrary to all preconceived ideas, that it at once met with an almost universal opposition.

Nearly all anatomists, and among them the celebrated Riolanus, of Paris (named the "prince of anatomists"), violently attacked Harvey's theory as false and absurd. Guy Patin, the successor of Riolanus as Dean of the Faculty of Medicine at Paris, did not allow any occasion to slip of casting ridicule on the "inventor" of the circulation of blood by means of his sarcastic wit. What were considered witticisms on the part of Patin, in those days, however, now fall cold and pointless in view of the confirmation of Harvey's discoveries, and the recoil of the weapon from whence the venom was shot has only served to lay low the marksman himself. The great merit of the labors of the English physiologist on the circulation of the blood is that they were only the result of observation and of the interpretation of facts taken as such, and a most brilliant proof of this was exhibited after his time. Harvey, through his experiments and reasonings, had been led to believe in the existence of capillary vessels in the interstices of the skin. He had merely divined them, for he never saw them. It was not till ten years after Harvey's death that a splendid confirmation of the doctrine of the general circulation was given through the discovery by Malpighi of the capillary vessels, the existence of which, as we have stated, the great anatomist had proclaimed as certain without having actually seen them.

Harvey was a man of even temper, and in his controversy with Riolanus—the only one in which he personally engaged—exhibited a modesty, forbearance, and discretion eminently worthy of imitation. His works—written in Latin—display elegant scholarship, and occasionally a considerable degree of eloquence. The library of the British Museum contains two manuscript works by him—"De Musculis et Motu Animalium" and "De Anatomia Universali." The latter, written in 1616, contains the germ of the doctrine of circulation. To him we owe almost all that we know touching the circulation of the blood in the human body, and modern investigation has added comparatively little to the results of his investigations. Harvey died at London, January 3, 1657, after living to see his discoveries universally acknowledged.

FILARIA IN THE EYE.*

By CHAS. S. TURNBULL, M.D., PH.D.

FILARIA IN THE EYE OF THE HORSE.

HEARING, through the kindness of a friend, that there was on exhibition, at a stable on Sansom street, a horse with a living worm in his eye, I at once made search for the curiosity. After finding and making a critical examination of the case, I was convinced that it was one of more than usual interest. At my desire Prof. Joseph Leidy visited the animal with me, and as he had never seen such a case before, he expressed himself emphatically concerning its novelty and interesting nature.

As all physicians are more or less interested in horses, I have described the case mentioned, as well as two others, both of which occurred in this country, have visited some of our most prominent veterinary surgeons, and consulted the best authorities on helminthology and hippophysiology, so as to be able to present a reliable and succinct account of the disease in question.

A heavily built dun horse, twelve years of age, which had been raised and worked upon a farm near Rochester, N. Y., was led out to the light, and through the partially opaque corner of his left eye could be seen a worm, several inches in length. It was white in color, and without the aid of any artificial means could be distinctly seen floating, wriggling and twisting about in the anterior chamber. The eye seemed very much irritated, as the horse continually endeavored to rub it, and the stimulus of light caused profuse lachrymation, and what is characteristic in such cases, at times only was the cornea hazy and the aqueous humor cloudy. The horse appeared perfectly healthy, was in excellent condition, and did not seem to be particularly annoyed by the presence of his unusual guest. The iris was of a good color, the action of the pupil perfect, lens clear, and remainder of the eye free from irritation.

The horse had been turned out early last spring (which will be remembered as an unusually wet one), and about that time the worm, which was one inch in length, was first discovered. Since then it has grown several inches, and at the time of this writing looks like a piece of cat-gut from four to five inches in length. On account of its incessant motion no details concerning the parasite's exact shape could be made out. As the present owner bought the horse for his eye, no one will be likely to have that satisfaction

This case makes the third which, so far as I can ascertain, has occurred in this country. The first on record was exhibited in this city in the latter part of the last century, and was reported by the late Judge Francis Hopkinson, in a paper read before the Philosophical Society, September 26th, 1783.[1] He says: "This worm was of a clear white color, in size and appearance much like a piece of white bobbin. It seemed to be from two and a half to three inches in length. The creature was in constant lively vermicular motion, sometimes retiring so deeply into the eye as not to be seen at all. I could not distinguish its head, neither end being perfectly exhibited while I viewed it; and, indeed, its motion was so brisk and constant as not to admit of so nice an examination. The horse's eye was exceedingly inflamed, swollen, and running, so that it was with difficulty the eye could be kept open for more than a few seconds at a time, and I was obliged to watch favorable moments for a distinct view of the tormentor. I believe (the Judge goes on to say) the horse was quite blind in that eye, for it appeared as if all the humors were confounded together, and that the worm had the whole orb to range in."

This worm, I think, must also have been in the anterior chamber, for if the eye had been in the disorganized condition represented by the Judge, the parasite could not have been seen at all.

The second case, which was never reported, occurred in the practice of Dr. Th. N. Corbyn, Ph.D., V.S., of this city, who kindly gave me the following interesting account of it: "I have had but one case in an experience extending over fifty years, and this occurred in the year 1833. The horse, the property of a physician in Alleghany City, Pa., had periodic attacks of ophthalmia. After the inflammation had subsided, I discovered the parasite floating in the aqueous humor. It was about two inches long. The case created quite a sensation at the time. I operated by penetrating the cornea, making the opening above; the humor spurted out, and with it came the worm, which looked like a fine piece of catgut. I prescribed low diet, with aperient medicine, and kept the eye covered, so as to exclude light. In fifteen days the eye recovered entirely."

In searching the literature of this subject the accompanying cuts, taken from Müller's "Zoologica Danica," vol. 3, p. 49, t. 109, f. 12, were chosen as best exhibiting the characteristics of the parasite under consideration.[2]

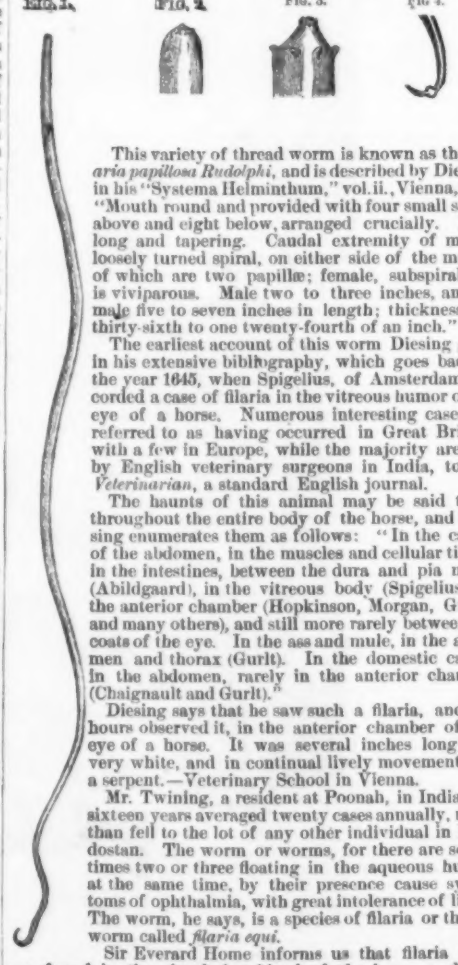
Fig. 1 represents the *Filaria papillosa Rudolphi*, natural size.

Fig. 2, the head, magnified.

Fig. 3 again shows the magnified head with the papilla squeezed out.

Fig. 4, magnified caudal extremity, supposed to be of a male.

FIG. 1. FIG. 2. FIG. 3. FIG 4.



This variety of thread worm is known as the *Filaria papillosa Rudolphi*, and is described by Diesing, in his "Systema Helminthum," vol. ii., Vienna, 1851: "Mouth round and provided with four small spines above and eight below, arranged crucially. Body long and tapering. Caudal extremity of male a loosely turned spiral, on either side of the margin of which are two papillæ; female, subspiral. It is viviparous. Male two to three inches, and female five to seven inches in length; thickness one thirty-sixth to one twenty-fourth of an inch."

The earliest account of this worm Diesing gives in his extensive bibliography, which goes back to the year 1645, when Spigelius, of Amsterdam, recorded a case of filaria in the vitreous humor of the eye of a horse. Numerous interesting cases are referred to as having occurred in Great Britain, with a few in Europe, while the majority are sent by English veterinary surgeons in India, to the *Veterinarian*, a standard English journal.

The haunts of this animal may be said to be throughout the entire body of the horse, and Diesing enumerates them as follows: "In the cavity of the abdomen, in the muscles and cellular tissue, in the intestines, between the dura and pia mater (Abildgaard), in the vitreous body (Spigelius), in the anterior chamber (Hopkinson, Morgan, Greve, and many others), and still more rarely between the coats of the eye. In the ass and mule, in the abdomen and thorax (Gurlt). In the domestic cattle, in the abdomen, rarely in the anterior chamber (Chaignault and Gurlt)."[3]

Diesing says that he saw such a filaria, and for hours observed it, in the anterior chamber of the eye of a horse. It was several inches long and very white, and in continual lively movement like a serpent.—Veterinary School in Vienna.

Mr. Twining, a resident at Poonah, in India, for sixteen years averaged twenty cases annually, more than fell to the lot of any other individual in Hindostan. The worm or worms, for there are sometimes two or three floating in the aqueous humor at the same time, by their presence cause symptoms of ophthalmia, with great intolerance of light. The worm, he says, is a species of filaria or thread worm called *filaria equi*.

Sir Everard Home informs us that filaria equi are found in the circulating blood of the horse, and it is supposed to be transmitted through that medium. Worms have been found in the cœliac artery of the ass, but of greater magnitude. Naturalists have discovered numerous genera and several species—the ascaris, tænia, filaria, strongula, ligula, etc.—as inhabitants of the body of the horse, sheep, ox, hog, deer, etc.

The most succinct account of this phenomenon is by Sir Chas. Percivall, V.S., in 1825, and published in the London *Veterinarian* for 1828. He says: "In low, humid situations in India, where frogs are prevalent, or where there is stagnant water, especially after an unusually wet season, worm in the eye is a very common occurrence. It is also seen in other parts during the cold months, from the beginning of October to the latter part of February, and especially during the continuance of an east wind. The symptoms are those of a conjunctivitis; the cornea is obscured by a nebulous effusion,' the eyelids are closed, and there is intolerance of light.

"On close inspection a small white worm can be discerned floating in the aqueous humor, at one time rising to the superior, at another sinking to the inferior portion of the anterior chamber.

"The method of treatment is by puncturing the cornea at its upper and inner margin, and allowing the parasite to escape with the aqueous humor. This spot is selected for the operation because the cornea is here least dense, and because the aqueous humor, which gradually reforms, will be least likely again to escape while the wound is healing.

"These worms find their way into the animal's body along with the water he drinks, either as fully developed parasites or as ova. Both the parasites and eggs are found in the stagnant waters of India."

The *Veterinarian* for 1864, p. 218, contains the account of a case where this species of worm was removed by the operation just described, one from either eye. Beer's cataract knife was used to make the incision. The Edinburgh *Veterinary Review*, vol. 6, for 1864, also contains a very interesting and humorous account of a similar case.

A fact of intense satisfaction to the lovers of horseflesh is, that in no case of operation for the removal of filaria has the function of the eye been more than temporarily disturbed.

Since commencing this paper I have learned through a friend, that Dr. Chas. J. Kipp, of Newark, N. J., exhibited at a recent meeting of the New York Ophthalmological Society, a fine specimen of filaria which he had removed from the anterior chamber of the eye of a horse. The Doctor will doubtless publish a detailed account of the case.

(To be continued.)

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* A Paper read before the Alumni Society of the Auxiliary Department of the University of Pennsylvania, Sept. 27th, 1878.—*Medical and Surgical Reporter.*

[1] *Trans.* Am. Philos. Soc., 1st Series, Vol. II.

[2] For those who are anxious to look up the minute anatomy of this worm, I would recommend Gurlt's "Pathological Anatomy of the Horse," and Leuckart's "Menschlichen Parasiten."

PREHISTORIC MOUNDS IN KANSAS.

ON a high bluff, about six miles west of town, near the residence of Mr. J. B. Stuart, on the Smoky Hill, stands an ancient mound, which was first noticed last September by Mr. George Wiseheart, of Illinois, while visiting in the family of Mr. Stuart. Mr. Wiseheart made some slight excavations into the mound, and, upon finding some remains of human bones, he reported the fact in town, which led some gentlemen to determine to explore it still further.

Accordingly, on Thursday, November 28th, a party visited the place, and there found the mound to be a very prominent object on the hill, and composed of stones, large and small, filled out with earth. The stones have all been brought to the spot and deposited by human hands, as no rock exists in its immediate vicinity. The whole work is about twenty-five feet in diameter, and is maniform in shape. There has been no attempt at anything like masonry in its structure, but the stones are arranged in curious, irregular circles, the inner one at the top of the mound being about six feet in diameter, surrounded by others of similar size, and still others smaller. There are numerous others of these circles made all around the mound, on every side, but more numerous on the south and southeast sides. They vary greatly in dimensions, but are all of the same general appearance, and cover quite a large extent of surface.

From the appearance of these circles within circles, it was thought that the mound might originally have been pyramidal, but the wear and tear of ages and rains and tempests have reduced it to its present form.

Upon digging into the tumulus many of the stones were found arranged into rude arches, but this was not general as far as explored.

Quite a quantity of bones and teeth were found, some human, some of large animals, and some belonging to rodents, but all were in such a decayed and fragmentary condition that it was not possible always to distinguish them particularly. Several small pieces of human skull were there, but none large enough to discover the race of the individuals. Some of the animal bones have evidently been subjected to the action of fire, and pieces of burnt clay or brick also indicated the presence of fire, though not a particle of charcoal was seen.

It was impossible to distinguish the manner in which the dead were buried, whether lying or sitting or doubled up, or in which direction the head or heads lay, as the bones were mingled indiscriminately in the most confused manner, a piece of skull lying in juxtaposition to a toe or hip bone, with the tooth of an unguiculate animal or the jaw of a small rodent close by.

No weapons or implements either of stone or bone were found, except some fragments of pottery, and these very small and composed of a peculiar black silicious clay, and some small tubes of bone, ornamented on the outside with spiral cuttings of a knife, and one little bone button.

Who built this tumulus? Some mounds in the United States have been assigned an age of two thousand years, and we have no doubt, judging from the state of decay of its contents, that this one is among the oldest.

For what purpose it was built is another interesting question. It is on the top of a high hill, and no alteration in the face of nature could ever have driven a brook or other stream from its vicinity. Water is too far away to allow the supposition that it ever was a permanent dwelling place.

The bluff on which this relic stands, although it has a very steep and abrupt south face, has a gradual and long slope toward the east. The mound does not stand on the summit of the hill, but a little way down this eastern slope, and this, with the peculiar little irregular circles of stone, with the charred bones of animals and the presence of fire, seems to make the most probable conjecture as to its origin to have been on some great sacrificial occasion, following the death of some great chieftain or renowned man, when all the people assembled for a period of mourning for the great or loved departed; looking to the east as the source of light and the hope of the tribe that the darkness of the tomb might thence in the distant future be illumined.—*Junction City Union.*